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STOCK ASSESSMENT AND BIOLOGICAL CHARACTERISTICS OF BURBOT IN LAKES OF INTERIOR ALASKA DURING 1989[1]

By

Robert Lafferty, James F. Parker,
and David R. Bernard

Alaska Department of Fish and Game
Division of Sport Fish
Anchorage, Alaska

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ABSTRACT

Abundance and/or indices of abundance were estimated for populations of burbot *Lota lota* in 18 lakes in interior Alaska. Sampling occurred from May through October 1989. Burbot greater than 300 millimeters (total length) were captured in all study lakes; however, only burbot 450 millimeters and larger were considered fully recruited to the gear used to capture burbot (hoop traps). Mean catch-per-unit of effort of fully recruited burbot per 48-hour set ranged from 0.12 burbot in T Lake to 7.11 burbot in Moose Lake. Average rate of tag loss among all populations was 3.5 percent within a year and 5.3 percent over a year. The abundance of fully recruited burbot was estimated using mark-recapture experiments in 10 lakes and ranged from 97 burbot in T Lake to 3,458 burbot in Lake Louise (in 1988). Rates of annual survival and recruitment were estimated for populations studied over multiple years. Annual rates of survival ranged from 35 percent in Lake Louise and Round Tangle Lake to 89 percent in Fielding Lake. Size and age compositions of burbot populations varied widely among lakes.

KEY WORDS: burbot, *Lota lota*, lakes, abundance, hoop traps, systematic design, random design, stratified design, otolith, mean length, length-weight, age, catch-per-unit of effort, survival rates, recruitment.

INTRODUCTION

A major sport fishery for burbot *Lota lota* occurs in the lakes near Glennallen and the Tanana River drainage (Figure 1). Much of the harvest occurs during the winter months from November to April using baited setlines or jigging. Harvests of burbot from these lakes increased, on average, 30% annually from 1977 to 1983, with the largest harvests occurring during the years 1984 to 1986 (Mills 1989). The lakes in the Glennallen area have historically supported the largest component of this harvest (Mills 1989). Harvests from lakes in the Glennallen area were greater than 10,000 burbot from 1984-1986, with a peak harvest of over 19,000 burbot occurring during 1985. The lakes of the Tyone River drainage (consisting of Lake Louise and Susitna and Tyone lakes) have historically supported over half the harvest of burbot in the Glennallen area (Mills 1989).

During 1987 and 1988, harvests of burbot in lakes near Glennallen and the Tanana River drainage have declined (Mills 1989). The decline in harvests can be attributed to decreasing abundance of burbot in lakes due to overfishing and more restrictive regulations governing the sport fishery (Parker et al. 1989). Emergency regulations adopted in 1987 for many of the lakes reduced the bag and possession limit for burbot to a maximum of five fish (in some cases less) and reduced the number of simultaneously fished hooks to a maximum of five.

The purpose of this project is to present biological information on burbot populations in selected lakes. This information is being used to assess the status, productivity, and ranges of sustainable yield of lacustrine burbot stocks. The objectives for work conducted during 1989 were the estimation of:

1. mean catch-per-unit of effort (CPUE) of burbot in 18 lakes as an index of abundance;
2. abundance of burbot in several lakes;
3. mean total length (TL) of captured burbot in 18 lakes;
4. mean length-at-age for burbot in several lakes;
5. parameters in the length-weight relationships of burbot populations in several lakes; and,
6. annual survival rates and recruitment in populations sampled in 1986, 1987, 1988, and 1989.

The burbot populations studied in the Tanana River drainage during 1989 were in Fielding, Harding, T, George, Sevenmile, Round Tangle, Shallow Tangle, Upper Tangle, Landlock Tangle, and Jack lakes (Figure 1). The burbot populations studied in the Glennallen area during 1989 were in Susitna, Hudson, Tyone, Moose, Tolsona, and Paxson lakes (Figure 1). Each lake has (or had) a popular sport fishery for burbot. Descriptions of each study lake are presented in Appendix A.

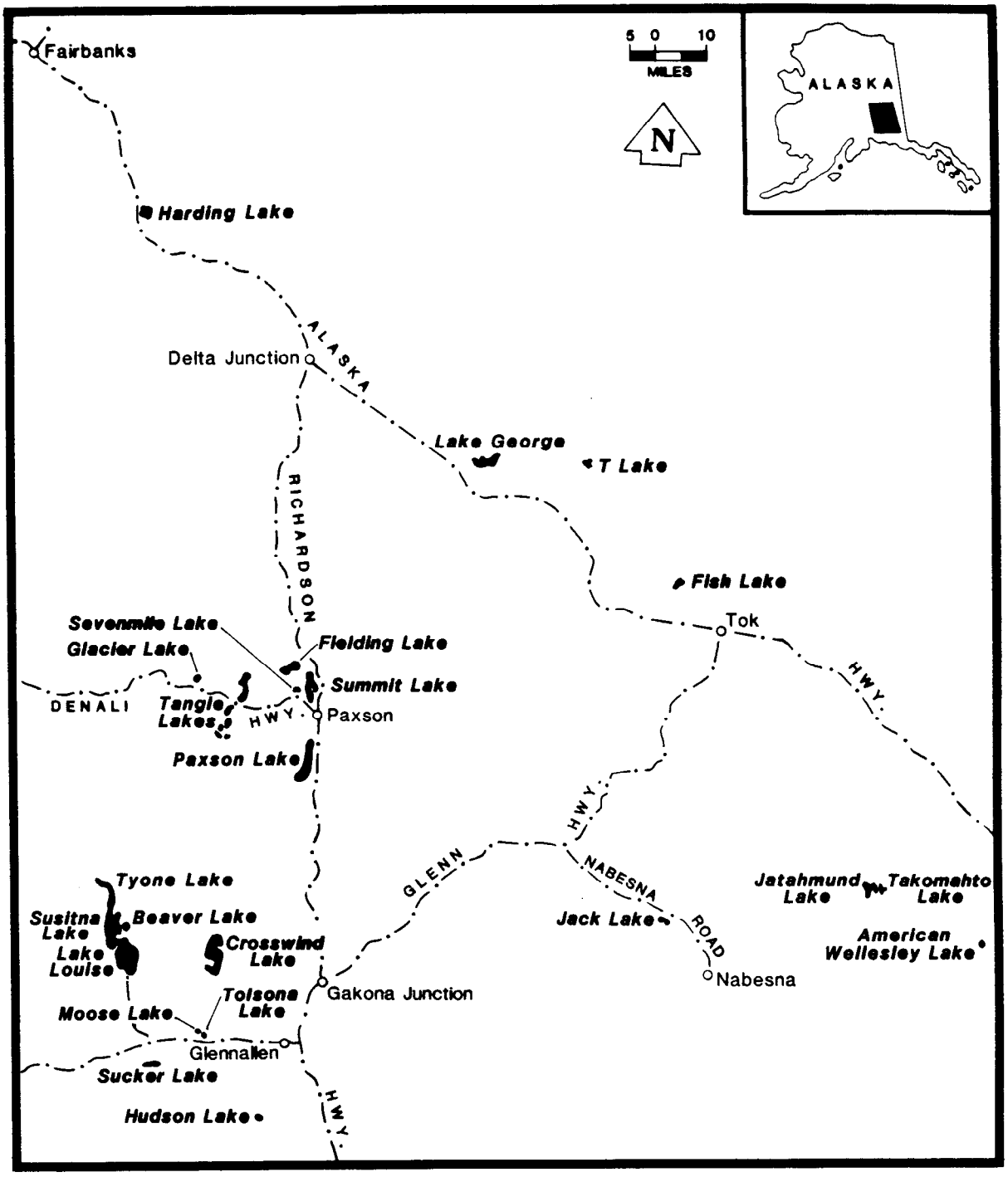

Figure 1. Location of lakes in the Tanana River drainage and near Glennallen that were included in studies of burbot populations in interior Alaska in 1989.

METHODS

Gear Description

Burbot were captured in hoop traps 3.05 m in length with seven 6.35 mm steel hoops (Figure 2). Hoop diameters tapered from 0.61 m at the entrance to 0.46 m at the cod end. Each trap was double throated (tied to the first and third hoop) with throats narrowing to an opening 10 cm in diameter. All netting material was knotted nylon 25 mm bar mesh, held together with No. 15 cotton twine, and treated with an asphaltic compound. Each trap was stretched with two sections of 12 mm galvanized steel conduit which were attached by snap clips to the end hoops of the trap. A numbered buoy was attached to the cod end of the trap with a polypropylene rope. Each trap was baited with Pacific herring *Clupea harengus pallasi* cut into chunks and placed in a 500 ml perforated plastic, screw-top container. Bait containers were placed unattached in the cod end of the hoop trap.

Study Design

Mean CPUE of burbot was estimated for 18 populations using a stratified-systematic survey design (Table 1). First, an overlay with parallel lines was placed across a map of the lake at a randomly chosen position such that the lines of the overlay were perpendicular to the long axis of the lake. Distances between adjacent lines in the overlay represented 125 m. Each parallel line was segmented into 125 m intervals with each interval corresponding to a potential sampling site[1]. The desired number of samples (Robson and Regier 1964) were compared with the number of sampling sites on the map. Parallel lines were randomly excluded until the desired number of samples was attained. Traps were set in transects corresponding to the position of each remaining parallel line. The first trap site along each transect was randomly chosen with every subsequent trap site 125 m apart.

To reduce sampling induced mortality of burbot resulting from decompression, no traps were set deeper than 15 m in high altitude lakes (650 m and higher). Since fully recruited burbot in these lakes are equally distributed among depths (Parker et al. 1989), sampling can be restricted to shallow waters without compromising the accuracy of the mean CPUE statistic as an index of abundance of these burbot. Furthermore, complete mixing of fully recruited burbot occurs across depths within a few days (Parker et al. 1989). Because partially recruited burbot (< 450 mm TL) are not evenly distributed across depths during summer (Parker et al. 1989), restricting sampling to less than 15 m in depth would bias estimates of mean CPUE statistics for that group. Selection of sampling locations in these deep lakes followed the same procedure as in other lakes, only a bathymetric map was used, and all locations below 15 m were not considered for sampling. The survey design was not confined to shallow waters in deep, low altitude lakes because burbot of all sizes are not evenly distributed across depths (Parker et al. 1989).

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[1] The distance of 125 m between traps was chosen to eliminate gear competition (Pearse and Conrad 1986).

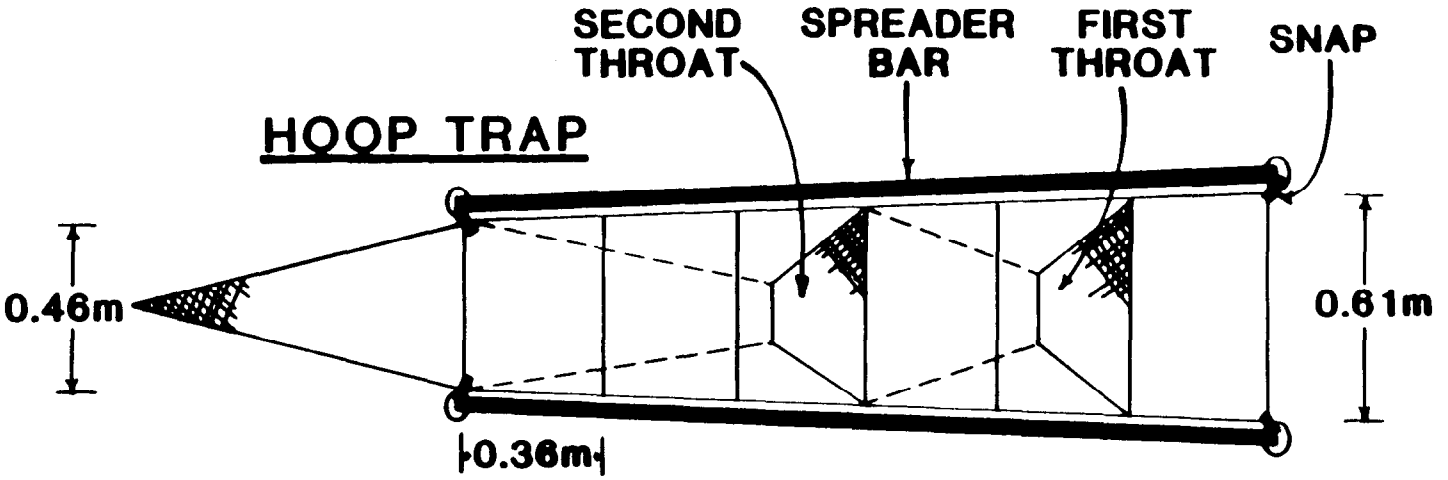

Figure 2. Schematic drawing of hoop traps used to catch burbot in interior Alaska in 1989.

Table 1. Numbers of sets and dates of sampling events for the stock assessment of burbot populations in 18 lakes in interior Alaska in 1989.

Lake	Area (ha)	Sampling: Event	Dates	Number of Sets	Lake	Area (ha)	Sampling: Event	Dates	Number of Sets
Fielding	538	1	6/26-30	180	Hudson	259	1	7/11-18	241
		2	9/22-26	239					
George	1,863	1	6/1-11	298	Louise[a]	6,519	1	6/1-17	1,498
Harding	1,000	1	9/18-22	120	Moose	130	1	5/21-24	62
							2	7/10-12	61
							3	9/15-17	60
Jack	150	1	7/19-22	120			4	10/4-6	60
Landlock	219	1	7/9-13	179	Paxson[a]	1,575	1	9/15-25	592
Tangle		2	8/7-11	179					
Round	155	1	6/24-27	120	Susitna[a]	3,816	1	6/15-7/1	1,396
Tangle		2	7/25-28	117					
Sevenmile	34	1	6/29-7/1	40	Tolsona	130	1	5/23-25	61
		2	8/3-5	40			2	9/12-14	61
Shallow	130	1	6/25-25	118	Tyone	389	1	6/30-7/3	202
Tangle		2	7/23-26	115					
Summit	1,651	1	7/14-17	119					
T	162	1	5/17-21	80					
		2	8/17-22	120					
Upper	142	1	7/7-10	118					
Tangle		2	8/5-8	118					
TOTALS	18,689		5/17-10/6						6,650

[a] All sets were located in depths < 17 m.

Each hoop trap was soaked for approximately 48 hours (hereafter referred to as a set). This length of fishing time has been shown to maximize the catch of burbot per set in lakes (Pearse and Conrad 1986). Traps were immersed and retrieved during daylight hours beginning on one end of the lake and progressing to the other end. On larger lakes, multiple crews (three members per crew: one person piloted the boat and recorded data while the other two handled traps and measured and tagged captured burbot) immersed and retrieved traps simultaneously. On smaller lakes, a single crew was used to immerse and retrieve traps. Each crew would immerse and retrieve from 50 to 80 traps in an 8-hour work day. Every new set received fresh bait, and old bait was discarded on shore.

Captured burbot were placed into a plastic tank during sampling. Each burbot was measured and those greater than 300 mm in total length (TL) received two marks. Burbot were tagged with an individually numbered Floy tag inserted in the musculature beneath the dorsal fin. The second mark, which was used to evaluate loss of Floy tags, was a finclip or hole punch to the opercle. Any burbot that was stressed from deep-water removal (usually an expanded gas bladder) or had trap-inflicted injuries was killed and dissected. Otoliths were removed from dissected burbot and the sex and maturity of these burbot were recorded. Ages were estimated from whole, polished otoliths by counting annuli.

Burbot were separated into two groups for analysis: those fully recruited to the hoop traps ($\geq$ 450 mm TL) and those partially recruited ($<$ 450 mm TL). Parker et al. (1987, 1988) showed that burbot recruited fully to the gear between 450 mm to 500 mm TL in most lakes. Although there are some exceptions to this rule, arbitrarily dividing the population into size groups negligibly biased estimated statistics for these exceptions.

Abundance, Survival Rates, and Recruitment

Burbot abundance was estimated with mark-recapture experiments using one of three estimators: (1) 1-year, two-sample estimators based on the Chapman model (1951); (2) 2-year, two-sample estimators based on the same model; and (3) multi-year estimators based on the Jolly-Seber model (Seber 1982). One-year, two-sample experiments were used in lakes sampled for the first time; 2 year, two-sample experiments were used on populations that had been sampled once in 1988; and Jolly-Seber models were used when a population had been sampled for at least 3 consecutive years. Mark-recapture histories for all populations studied are in Appendices B1-B4.

The Chapman modification of the Petersen model (Seber 1982) is:

$$\hat{N} = \frac{(M+1)(C+1)}{(R+1)} - 1 \qquad [1]$$

$$\hat{V}(N) = \frac{\hat{N}(M-R)(C-R)}{(R+1)(R+2)} \qquad [2]$$

where:

N = abundance;

M = number of marked burbot released alive into the population during the earlier sampling event;

C = number of burbot caught in the later sampling event; and

R = number of burbot marked in the earlier event and recaptured during the later event.

Equations 1 and 2 were used for both kinds of two-sample experiments. However, bias from growth recruitment between sampling events in the 2-year, two-sample experiments was culled from the experiment using the techniques of Robson and Flick (1965). Burbot recaptured in lakes other than the one in which they were released were excluded from the mark-recapture experiments.

The open population model of Jolly (1965) and Seber (1965) is:

$$\hat{M}_{i,i+1} = \frac{R_{i,i+2}\, M_{i+1}}{R_{i+1,i+2}} + R_{i,i+1} + D_{i,i+1} \qquad [3]$$

where:

M_s = number of marked burbot released alive into the population during sampling event "s";

$M_{s,t}$ = number of marked burbot released alive into the population during sampling event "s" that are still alive just prior to sampling event "t";

$R_{s,t}$ = number of marked burbot released in sampling event "s" and recaptured during event "t"; and,

$D_{s,t}$ = number of marked burbot released in sampling event "s," recaptured during event "t", and not returned to the population (usually due to death).

An estimate of the survival rate between sampling events "s" and "t" was calculated as:

$$\hat{S}_{i,i+1} = \frac{\hat{M}_{i,i+1}}{M_i} \; . \qquad [4]$$

Recruitment and abundance were estimated as follows:

$$\hat{N}_i = \frac{\hat{C}_i \hat{M}_{i-1,i}}{R_{i-1,i}} \qquad [5]$$

$$\hat{A}_{i-1,i} = \hat{N}_i - \hat{N}_{i-1}\,\hat{S}_{i-1,i} \qquad [6]$$

where:

N_t = abundance just prior to sampling event "t";

C_t = number of burbot captured during sampling event "t"; and,

$A_{s,t}$ = number of recruits added to the population between sampling events "s" and "t".

The Jolly-Seber model has the same assumptions as does the Petersen model, except that mortality and recruitment are permitted between sampling events. Equations 4-6 (and variances) were calculated with the program JOLLY as described in Pollock et al. (1985) and Brownie et al. (1986).

For those populations that have been in the stock assessment program since 1986 and earlier, a combination of estimation methods (Jolly-Seber and Petersen) was used to extend the range of the estimates according to the approach suggested in Pollock (1982). Gilbert (1973) has demonstrated the Jolly-Seber model to be unbiased in mark-recapture experiments with large sample sizes and with large numbers of recaptures. To maximize sample sizes and recaptures, sampling events separated by less than 4 weeks were pooled into one event. In those instances when an abundance estimate was not available for the first year (a Petersen estimate), equation 6 was used to produce an estimate of recruitment between the first two sampling periods. In this case, the variance of the first estimate of recruitment was calculated as follows (Goodman 1960):

$$\hat{V}[\hat{A}_{o,1}] = \hat{V}[\hat{N}_1] + \hat{V}[\hat{N}_o]\hat{S}_{o,1}^2 + \hat{N}_o^2\hat{V}[\hat{S}_{o,1}] - \hat{V}[\hat{N}_o]\hat{V}[\hat{S}_{o,1}]. \qquad [7]$$

Because of uncertainty as to the length at full recruitment to sampling gear for burbot in Landlock Tangle, Round Tangle, Shallow Tangle, Upper Tangle, and Sevenmile lakes, a single estimate of abundance was computed for each population (Parker et al. 1989).

Mean CPUE

Mean CPUE was estimated for partially (< 450 mm TL) and fully recruited burbot (≥ 450 mm TL) in 18 populations during 28 sampling events following a two-stage sampling design (Sukhatme et al. 1984). Transects were considered the primary units and sets along transects as secondary units. Although transects

had an equal probability of being selected for the survey, the number of sets was different from transect to transect. The following equation was used to calculate unbiased estimates of mean CPUE:

$$\overline{CPUE} = \frac{\sum_{i=1}^{n} \sum_{j=1}^{m_i} x_{ij}}{\sum_{i=1}^{n} m_i} \qquad [8]$$

where:

x_{ij} = catch of transect$_i$; at sample site$_j$,

n = number of transects; and,

m_i = number of sets on transect x_i.

Catch was not adjusted for sets with soaks a few hours different from 48 hours because burbot rarely enter traps during the daylight hours (Pearse and Conrad 1986).

The formula for calculating the variance of mean CPUE in Equation 8 requires knowledge of the maximum number of sets (secondary units) in each lake (Cochran 1977 and Sukhatme et al. 1984). Since the exact "area" that the average trap fished is unknown, the maximum number of sets is also unknown. Since the variances for estimates of mean CPUE (Equation 8) could not be calculated, estimates of mean CPUE were based on arithmetic means and their variances were calculated even though they may be slightly biased:

$$\overline{CPUE} = \bar{\bar{x}} = \frac{1}{n} \sum_{i=1}^{n} \frac{1}{m_i} \sum_{j=1}^{m_i} x_{ij} \qquad [9]$$

$$V[\overline{CPUE}] = \sum_{i=1}^{n} \frac{(\bar{x}_1 - \bar{\bar{x}})^2}{n(n-1)} + \sum_{i=1}^{n} \sum_{j=2}^{m_i} \frac{(x_{ij} - x_{i,j-1})^2}{2\, n^2\, m_i\, (m_i - 1)} \qquad [10]$$

Equation 10 was composed of elements taken from Sukhatme et al. (1984) for two-stage sampling with primary units of equal size (variance among transects) and from Wolter (1984) for unbiased estimation of variance from systematically drawn samples (variances within transects). The x_{ij} terms were arranged in serial order along transects for the mean CPUE calculations. In the instance where data from a set are missing, the transect was redefined into smaller transects with contiguous sets. Finite population correction factors were excluded from Equations 10, 11, and 12 because the maximum number of sets is unknown.

Estimates of mean CPUE were post-stratified by depth according to procedures described in Sukhatme et al. (1984) and Pearse and Conrad (1986):

$$\overline{CPUE}_{st} = \sum_{h=1}^{L} W_h \, \overline{CPUE}_h \qquad [11]$$

$$V[\overline{CPUE}_{st}] = \sum_{h=1}^{L} W_h \, V[\overline{CPUE}_h] + \sum_{h=1}^{L} \frac{(1-W_h)V[\overline{CPUE}_h]}{n} \qquad [12]$$

where:

L = the number of strata; and

W_h = ratio of the area covered by stratum h to the area of the lake.

Average catch by depth was plotted for each sampling event in which 20 or more burbot were captured. In these plots, depths at which average catch by depth changed dramatically were chosen as the boundaries between strata. The weights (W_h) were calculated as averages over the years of the fraction of sets that had been within each depth stratum.

When a boundary between strata cut across a transect in the systematic design, each part of the dissected transect was considered a new transect, each within its separate stratum. In those cases where a new transect only consisted of one set, the datum was excluded from the analysis.

Stratified estimates of mean CPUE were calculated in all instances where average catch by depth changed dramatically. In these instances, unstratified estimates were calculated as well. If the two estimates (stratified and unstratified) were dissimilar by an amount greater than the arbitrary standard of half the standard error of the larger estimate, the stratified estimate was reported as the more accurate estimate. Otherwise, the unstratified estimate was reported.

Multiple recaptures during a given sampling event were treated differently for CPUE estimates than mark-recapture experiments. In mark-recapture experiments, burbot captured "k" times were considered captured but once; to estimate mean CPUE, these burbot were considered captured "k" times.

Length and Weight

Measurements of weight were limited to burbot greater than 600 mm TL to improve the existing length-weight relationships already published (Parker et al. 1987, 1988, and 1989). When sample sizes of lengths and weights were large, parameter estimates of allometric length-weight relationships were estimated using the iterative nonlinear least squares technique of Marquardt (1963). This method is similar to performing a series of ridge regressions with an algorithm that is a compromise between Gauss-Newton and steepest

descent. Fifty-five separate sets of estimates of the parameters were calculated with each calculation beginning with a new set of initial values. The initial values of the allometric constant ranged from 2.0 to 4.0 by increments of 0.2; the initial values of the linear constant ranged from 4.0 to 12.0 by increments of 2.0. Output from these calculations were plotted as an isopleth diagram of the sum of squares of the residuals from each set of initial values. The parameter estimates with the lowest sum of squares were reported.

RESULTS

Length Distributions

Of the seven burbot populations sampled twice during 1989, the populations in Fielding, Moose, Tolsona, and Shallow Tangle lakes had length distributions that were significantly different between sampling events (Kolmogorov-Smirnov two-sample test, $P < 0.05$; Figure 3). Length distributions of burbot in Fielding and Shallow Tangle lakes shifted towards smaller burbot from June to August. Of the four sampling events in Moose Lake, the length distribution from the sampling event in May was significantly different than the length distributions from sampling events in July, September, and October. For the two sampling events in Tolsona Lake, length distributions had modes that ranged from 500 mm to 600 mm TL.

Most of the length distributions from the sampled burbot populations have ascending left limbs with modes between 400 mm and 600 mm TL (Figures 3 and 4). Exceptions are the burbot populations at higher elevations in lakes located on the Denali Highway (Shallow Tangle, Sevenmile, and Landlock Tangle lakes). These burbot populations had length distributions with no ascending left limbs as seen in previous years (Parker et al. 1987, 1988, and 1989). Of the remaining study populations, modes of length distributions ranged from 400 mm to 450 mm TL in Harding Lake; 500 mm to 550 mm TL Susitna, Tyone, and Summit lakes; 550 mm to 600 mm TL in Hudson Lake and all four events in Moose Lake; and 600 mm to 650 mm TL in Lake Louise and George Lake. The mode of the length distribution from the population in Jack Lake ranged from 400 mm to 500 mm TL. Length distributions of burbot in Paxson and T lakes were bimodal, ranging from 550 mm to 600 mm and 650 mm to 700 mm TL for the population in Paxson Lake, and from 400 mm to 450 mm and 500 mm to 550 mm TL for the population in T Lake.

Movement of Tagged Burbot Between Lakes

Most lakes studied during 1989 were either geographically isolated or separated by lengthy rivers. The exceptions were the populations in the (1) Lake Louise Complex (consisting of Lake Louise and Susitna and Tyone lakes); (2) Tangle Lake Complex (consisting of Upper, Round, and Shallow Tangle lakes); (3) Summit and Paxson lakes; and (4) Moose and Tolsona lakes. Lakes in these four complexes are connected with short rivers, or, in the case of Moose and Tolsona lakes, an intermittent stream.

Although there was movement of tagged burbot between lakes in these complexes, the extent of this movement was considered limited. Of the 1,931 tagged

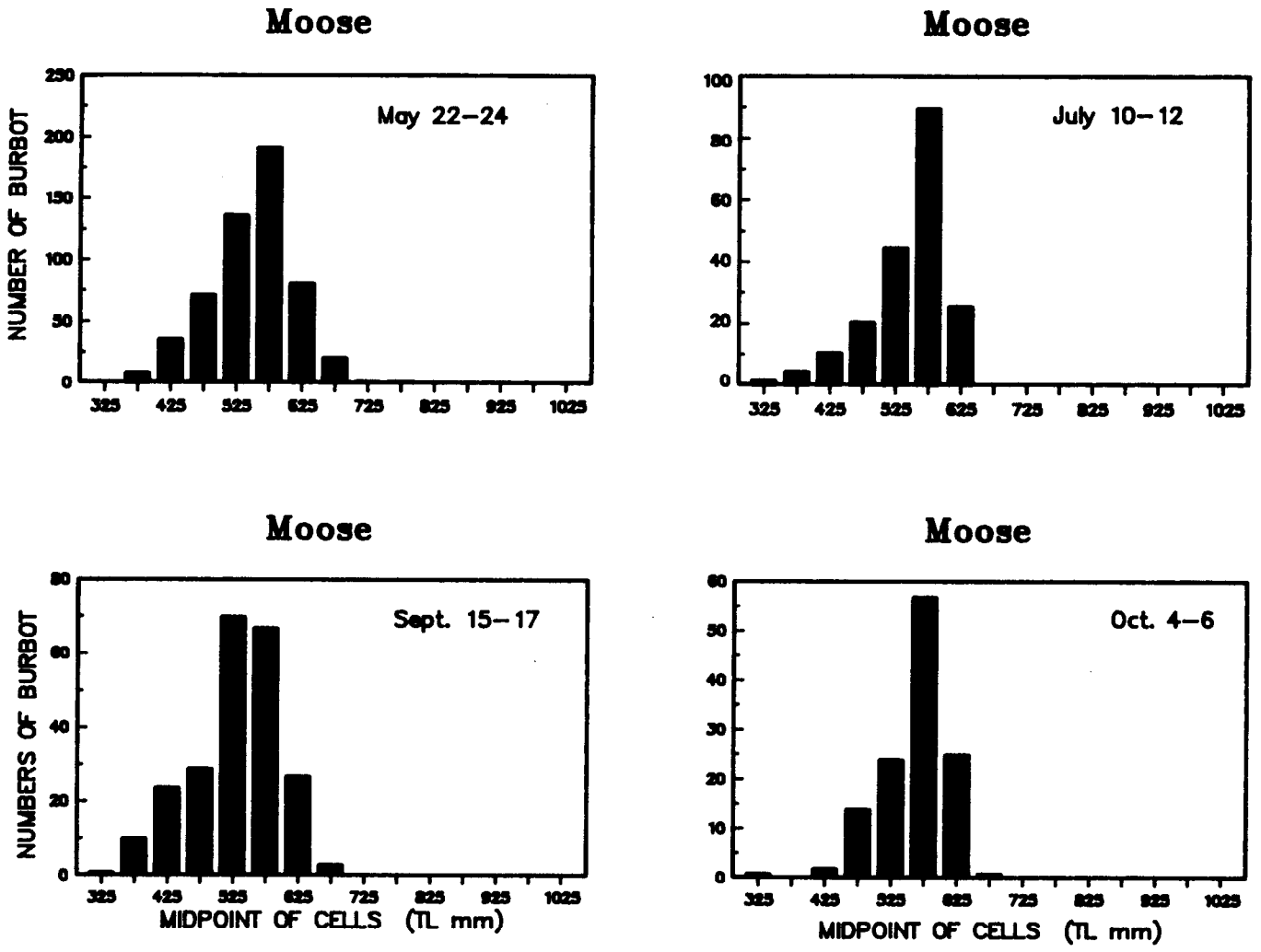

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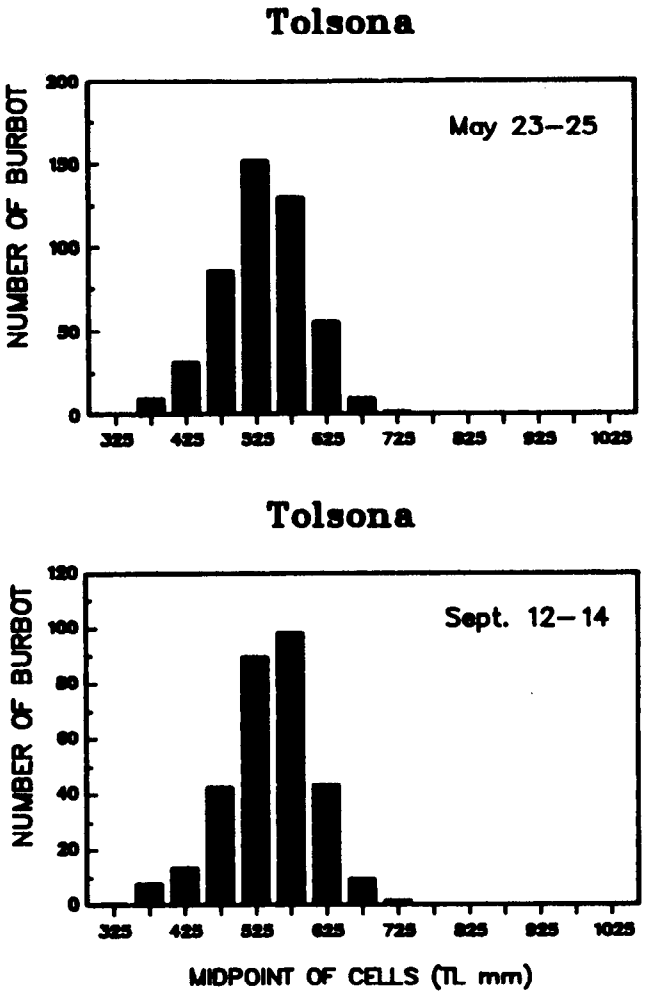
Figure 3. Length-frequency histograms of burbot captured during each sampling event in 1989 in which size distributions were significantly different by event ($\alpha = 0.05$) or the hiatus between events was greater than 3 months.



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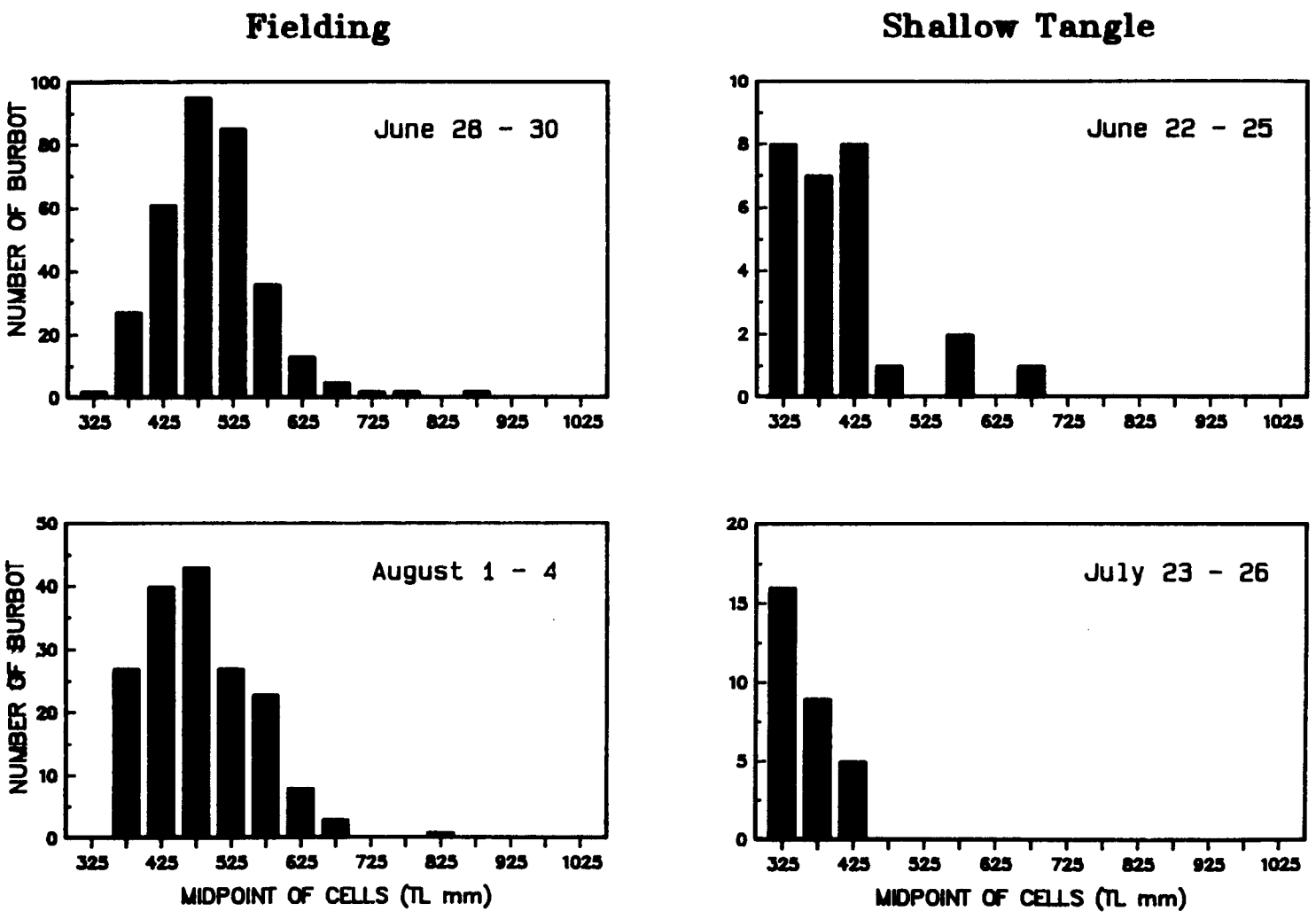

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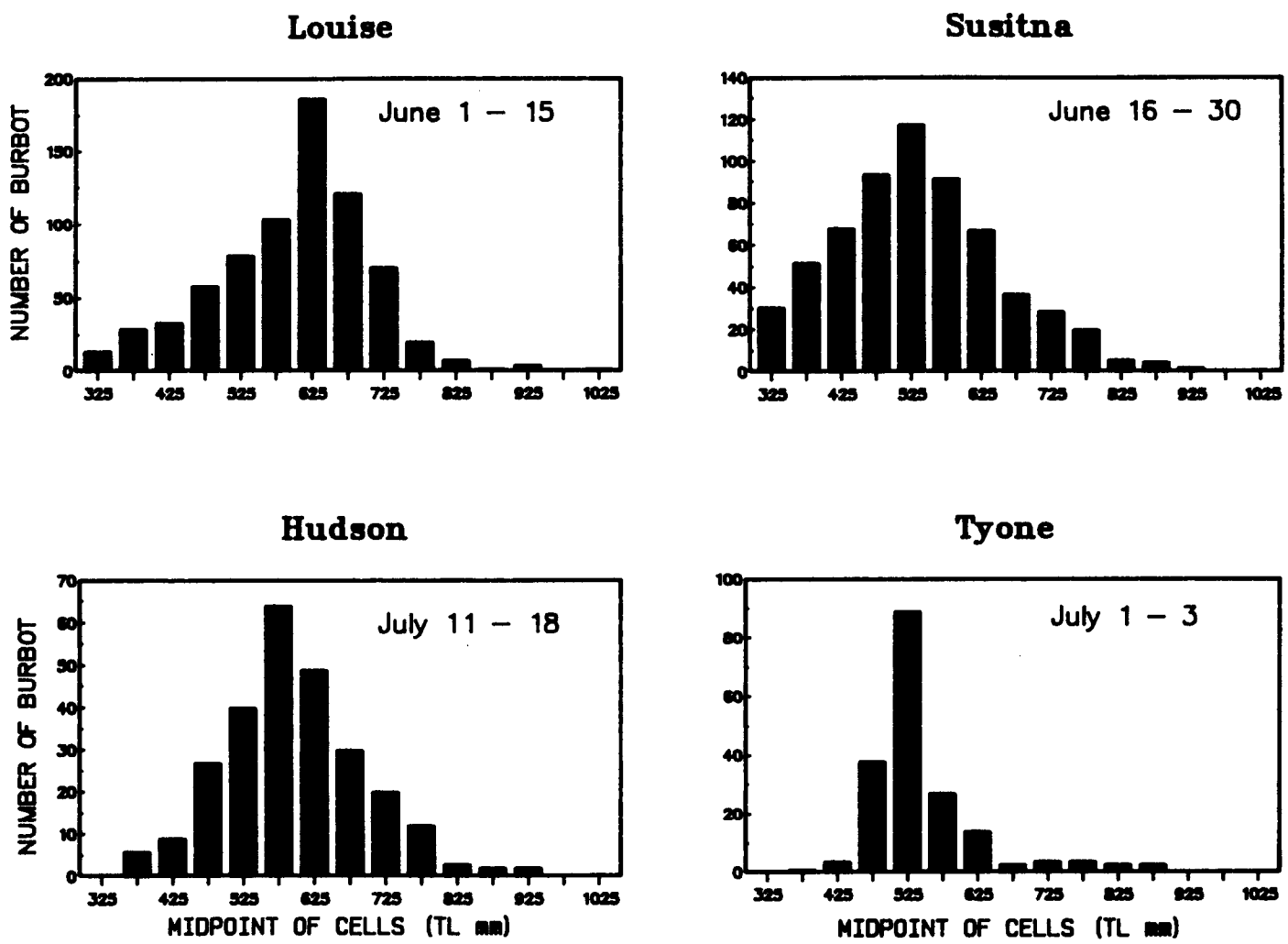

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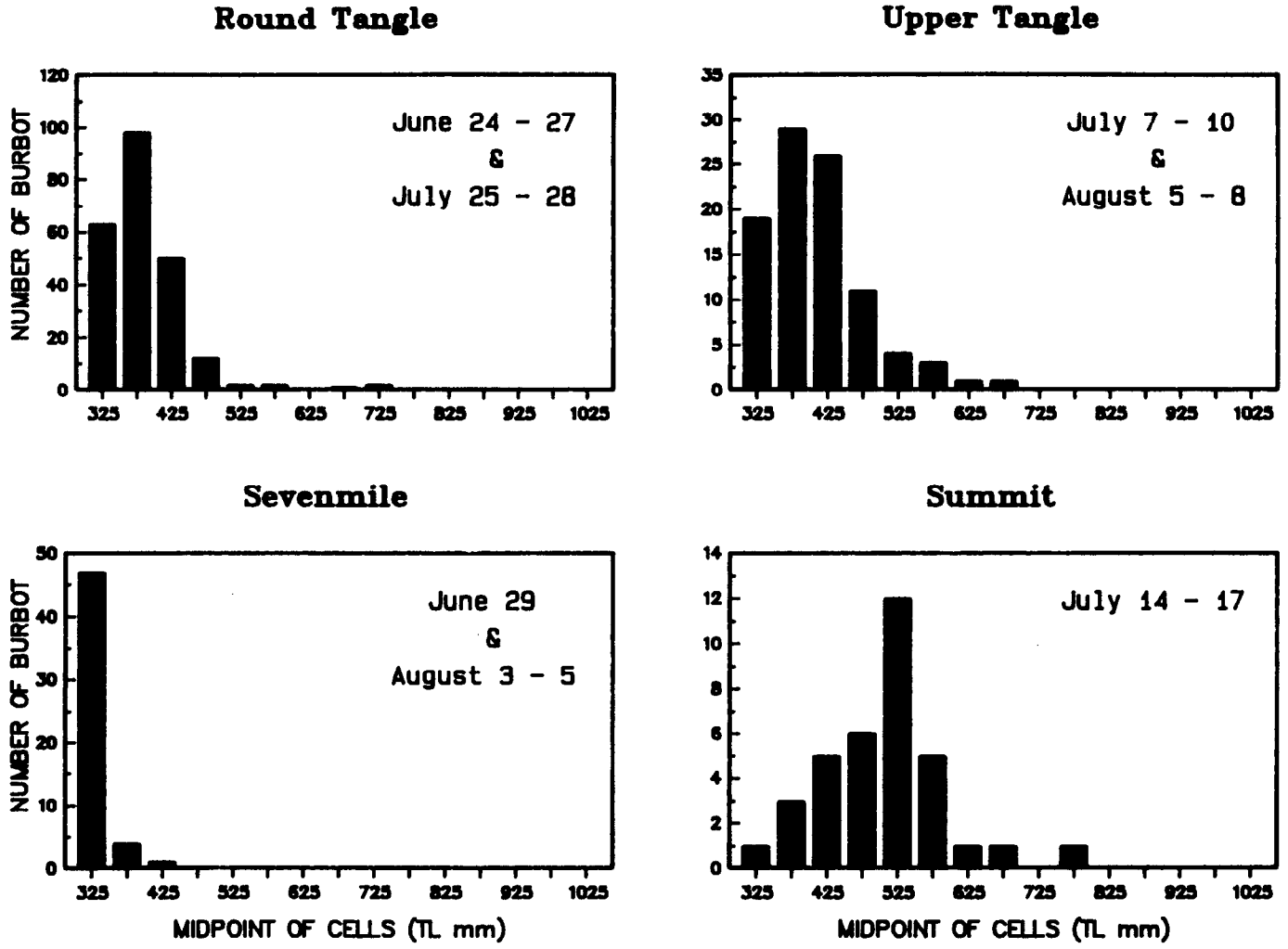
Figure 4. Length-frequency histograms of burbot captured during each sampling event in 1989 in which size distributions were not significantly different by event (α = 0.05).



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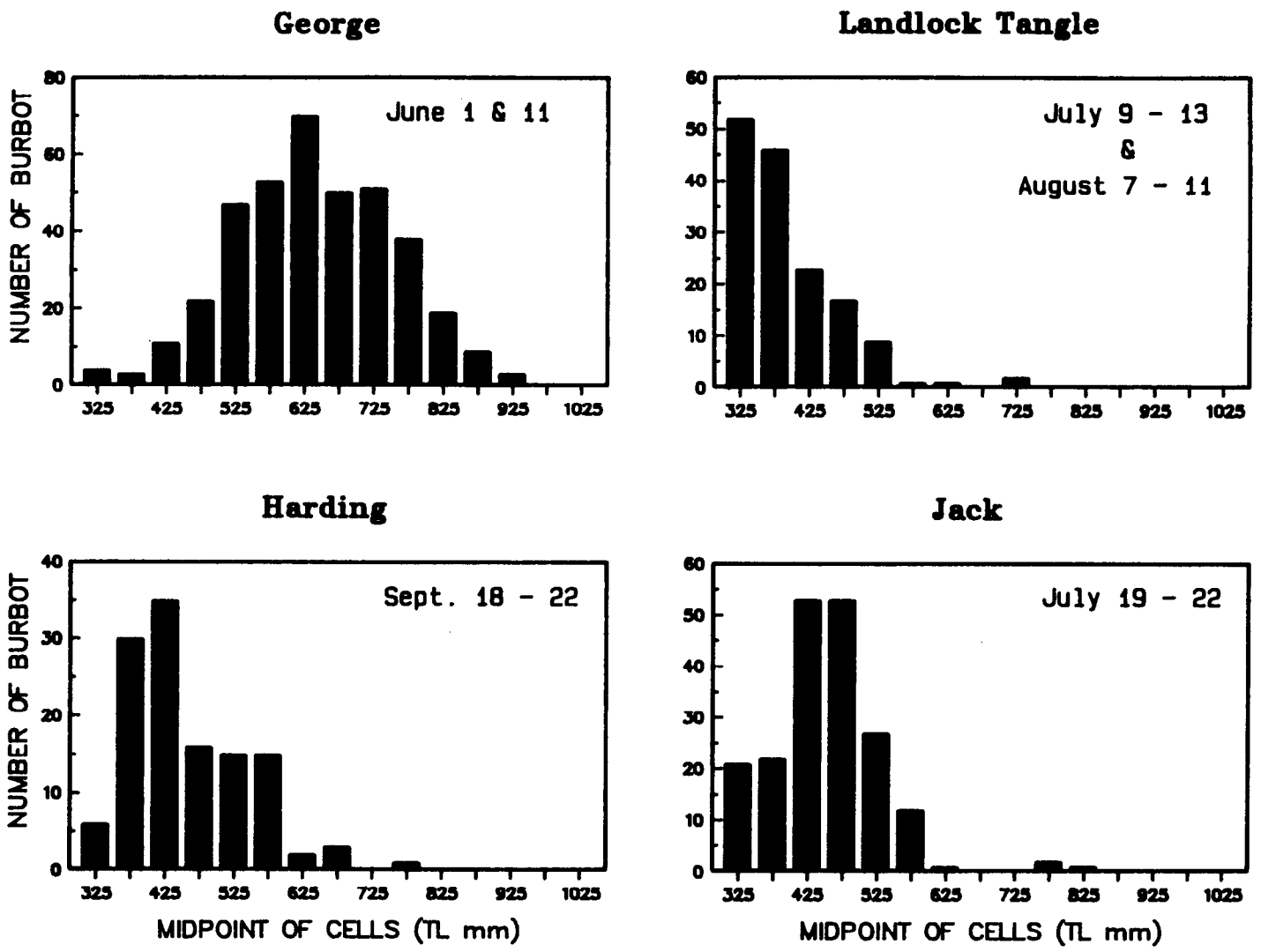

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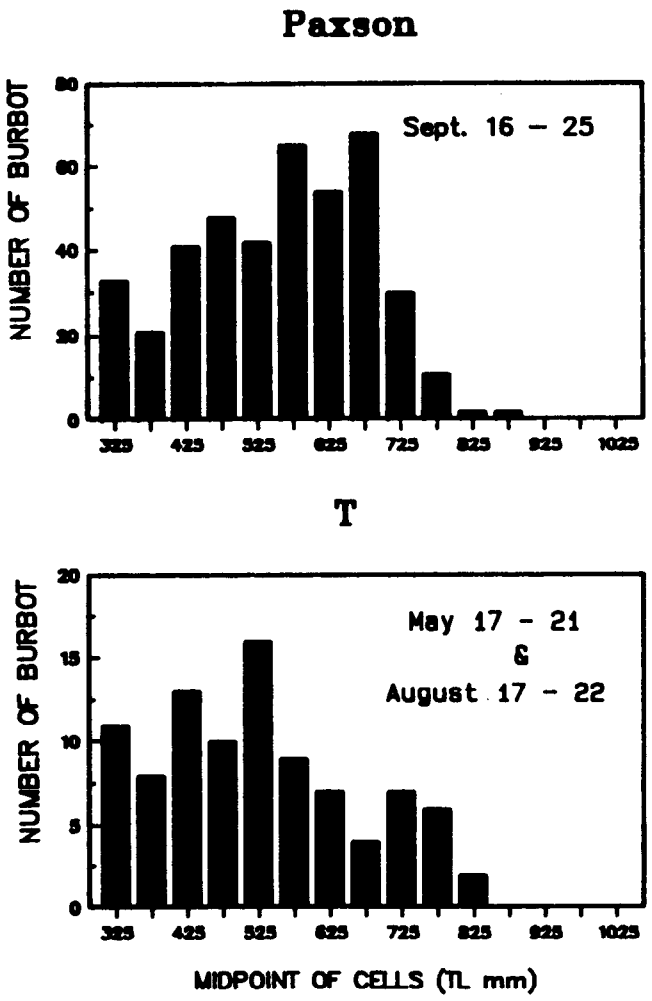

Figure 4. (Page 4 of 4).

burbot released into Lake Louise since 1986, only 3 were recaptured by our crews in Susitna Lake and 2 in Tyone Lake during 1989. Of the 859 tagged burbot released into Susitna Lake since 1986, none were recaptured by our crews in Lake Louise and 1 in Tyone Lake during 1989. Of the 786 burbot tagged and released into Tyone Lake since 1986, only 2 were recaptured in Susitna Lake and 1 in Lake Louise during 1989. Voluntary tag returns from anglers indicate greater movement of tagged burbot between the bodies of water in the Lake Louise complex (Appendix B5). Of the 18 voluntary tag returns, 6 tags (33%) were recoveries from different lakes than which they were tagged. However, these sample sizes are small and we have greater confidence in our directed sampling due to greater sample sizes.

There was also limited movement of tagged burbot between lakes of the Tangle Lake complex over the duration of the mark-recapture experiments. Three of 36 burbot recaptured in Round Tangle Lake during 1989 had been released in Shallow Tangle (2) and Upper Tangle (1) lakes during 1988. Of the 17 burbot recaptured in Upper Tangle Lake in 1989, four had been released into Shallow (1) and Round Tangle (3) lakes during 1988. All recaptured burbot in Shallow Tangle Lake were originally released into Shallow Tangle Lake during 1989. None of the tagged burbot released in 1989 into the Tangle lakes were recaptured outside of the lake in which they were released.

Of the 2,235 tagged burbot released into Paxson Lake over the years, only one burbot has been reported in an adjacent body of water. An angler returned the tag from a burbot caught 1 mile downstream of the outlet from Paxson Lake. There has been no evidence of tagged burbot moving between Paxson and Summit lakes.

Only one tagged burbot from Moose Lake has been recaptured in Tolsona Lake during sampling. Up to ten tagged burbot from Moose Lake have been recorded passing the weir on Our Creek during the spawning migration of Arctic grayling *Thymallus arcticus* in 1989 (personal communication, Wilson Potterville, ADFG Glennallen). The purpose of the weir is to concentrate Arctic grayling for the taking of eggs and thus the weir is in place only for a short duration. Of the ten tagged burbot that were passed through the weir, eight returned to Moose Lake before the weir was removed.

Sampling Mortalities

In past years of sampling, burbot captures from depths greater than 17 m resulted in high mortality rates (Parker et al. 1989). During 1989, sampling was restricted to less than 17 m in several deep lakes to reduce sampling mortality. By restricting our sampling in deep lakes to shallow depths, we reduced the kill of burbot from 401 fish during 1988 (Parker et al. 1989) to 111 fish during 1989, even though we increased our sampling effort in many of the deeper lakes (Appendix B6).

Tag Loss

The estimated rate of tag loss pooled over all populations studied was 3.5% between sampling events in the same year (Table 2). The rate of tag loss over the winter was 5.3%. The estimated rates of tag loss over 2 years and 3 years

Table 2. Rates of tag loss for burbot in interior Alaskan lakes.

	During Summer				Overwinter				Two Years				Three Years			
Lakes	Recaptured w/o Tags	All	Fraction w/o Tags	SE	Recaptured w/o Tags	All	Fraction w/o Tags	SE	Recaptured w/o Tags	All	Fraction w/o Tags	SE	Recaptured w/o Tags	All	Fraction w/o Tags	SE
Hudson					6	54	0.111	0.044	5	17	0.294	0.117				
Louise					1	19	0.053	0.054	1	19	0.053	0.054	0	8	0.000	0.000
Moose	1	82	0.012	0.012	2	191	0.010	0.007	12	125	0.096	0.027	0	92	0.000	0.000
Paxson	2	83	0.024	0.017	6	125	0.048	0.019	5	71	0.070	0.031	2	23	0.087	0.061
Susitna					2	24	0.083	0.059	0	5	0.000	0.000	0	1	0.000	0.000
Tolsona	3	26	0.115	0.065	1	113	0.009	0.009	1	84	0.012	0.012	0	84	0.000	0.000
Tyone					1	34	0.029	0.030	2	1	2.000	0.000	0	4	0.000	0.000
Fielding	2	38	0.053	0.017	11	58	0.190	0.022	4	23	0.170	0.017	2	4	0.500	0.032
George					4	13	0.310	0.026	0	5	0.000	0.000				
Jack					0	29	0.000	0.000								
Harding					0	9	0.000	0.000	1	5	0.200	0.036	1	2	0.500	0.045
Round Tangle	0	10	0.000	0.000	2	14	0.014	0.027	0	5	0.000	0.000	0	1	0.000	0.000
Shallow Tangle	0	2	0.000	0.000	0	1	0.000	0.000	0	0	0.000	0.000	0	0	0.000	0.000
Upper Tangle	0	3	0.000	0.000	1	3	0.333	0.062	1	4	0.250	0.044	0	1	0.000	0.000
Landlock Tangle	0	3	0.000	0.000					1	5	0.200	0.032	0	0	0.000	0.000
Summit					0	2	0.000	0.000	2	11	0.180	0.037	0	3	0.000	0.000
T	1	7	0.143	0.058	0	6	0.000	0.000	1	11	0.091	0.036	0	2	0.000	0.000
Sevenmile	0	1	0.000	0.000	0	9	0.000	0.000	1	2	0.500	0.069	0	2	0.000	0.000
TOTAL	9	255	0.035	0.012	37	704	0.053	0.008	13	393	0.033	0.009	5	227	0.022	0.010

were 3.3% and 2.2%, respectively. Throughout the duration of the mark-recapture experiments, there was no evidence of regenerated fins on any of the recaptured burbot with tags.

Abundance

Estimates of the abundance of fully recruited burbot in Fielding, Sevenmile, T, Moose, Tolsona, Jack, Landlock Tangle, Round Tangle, Shallow Tangle, and Upper Tangle lakes ranged from 97 to 1,234 (Table 3). Coefficients of variation (cv) for the estimates ranged from 10.7% to 53.1%. Six of the estimated abundances had coefficients of variation greater than 25%; five of these lakes are located on the Denali Highway. The estimates of abundance of fully recruited burbot in Moose Lake decreased over the sampling intervals of 1989; all three estimates, however, overlapped in their 95% confidence intervals. All sizes of burbot were combined for the estimates of abundance for lakes in the Tangle Lake complex due to small numbers of captured and recaptured burbot. Estimates of the abundance of partially recruited burbot could only be determined for Fielding (1,165), Sevenmile (352), and Jack lakes (1,234) (Table 3). Insufficient numbers of small burbot were captured in other lakes to allow estimation of partially recruited burbot.

Estimates of the abundance of fully recruited burbot were relatively stable in Fielding Lake from 1985 through 1989; estimates ranged from 216 to 411 burbot (Table 4). Estimates of the abundance of fully recruited burbot in Lake Louise and Paxson, Tolsona, and Round Tangle lakes decreased over time (Table 4). Most dramatic were the decreases in abundance of fully recruited burbot in Paxson Lake and Lake Louise. In these lakes, the abundance of fully recruited burbot decreased from highs of 9,111 and 6,990 burbot, respectively, in 1986 to lows of only 2,402 and 3,458 burbot, respectively, in 1988. The abundance estimates of fully recruited burbot in Tolsona and Round Tangle lakes also decreased over time, but to a lesser extent. Abundance of fully recruited burbot in Tolsona decreased from 1,901 in 1986 to 1,092 in 1989, with a decrease in abundance between spring and fall sampling, whereas in Round Tangle Lake, abundance decreased from 1,241 burbot in 1986 to 755 burbot in 1989. The estimates for Tolsona Lake exhibited the lowest amount of fluctuation in the coefficient of variation for the duration of the mark-recapture experiment (6.3% to 13.6%). The estimates for Lake Louise and Round Tangle Lake have coefficients of variation above 25% throughout the mark-recapture experiments (26.1% to 47.4%).

The multiple-year mark-recapture experiments conducted in Moose and Hudson lakes may have been compromised due to the same finclip being applied to consecutive sampling events[2]. Using the largest and smallest number of recaptured burbot (including tag loss), estimates of the possible extremes of abundance of fully recruited burbot and rates of annual survival and recruitment were estimated for both these lakes (Table 5). The difference between the upper and lower abundance estimates, survival rates, and recruitment estimates disappear for Moose Lake during 1989, whereas in Hudson Lake, the differences persist into 1989. During the three sampling events of 1989 in Moose Lake,

[2] The confusion occurs when a recaptured burbot with tag loss has a finclip that represents two different sampling events.

Table 3. Estimated abundance (N) of burbot partially and fully recruited to sampling gear from lakes in interior Alaska in 1988 and 1989.

Lake/Date	Size[a]	Number of Marked Burbot Released	Number Caught Second Event	Number Recaptured	$\hat{N}$	SE[$\hat{N}$]	CV[$\hat{N}$][b]
Fielding	fully	136	64	23	370	53	14.3%
6/26-9/26/89	partially	175	105	15	1,165	248	21.3%
Sevenmile	fully	0	0	0			
6/29-8/5/89	partially	21	31	1	352	187	53.1%
T	fully	48	15	7	97	21	21.6%
5/17-8/22/89	partially	21	9	0			
Jack	fully	135	77/100[c]	19	323	52	16.1%
9/8/88-7/22/89	partially	104	93	7	1,234	363	29.4%
Moose							
5/26-9/16/88	fully	429	216	35	2,591	373	14.4%
5/21-7/10/89	fully	425	115	45	1,073	115	10.7%
7/10-9/15/89	fully	160	132	28	737	108	14.6%
9/15-10/4/89	fully	176	147	29	872	128	14.6%
Tangle lakes							
Landlock	combined	51	74	3	975	408	41.8%
Round	combined	153	68	10	965	314	32.5%
Shallow	combined	27	30	2	289	159	55.0%
Upper	combined	101	68	7	879	303	34.5%

[a] For all populations, burbot ≥ 450 mm TL were considered fully recruited to the gear while smaller fish were considered to be partially recruited.
[b] Coefficient of variation.
[c] Culled for recruitment between 1988 and 1989 (Robson and Flick 1965).

Table 4. Estimates of survival rates, recruitment, and abundance from Jolly-Seber and other methods for several populations of burbot (≥ 450 mm TL) from interior Alaskan lakes.

	Date and Abundance		Survival Rate	Date and Abundance		Survival Rate	Date and Abundance		Survival Rate	Date and Abundance		Survival Rate	
	Recruitment			Recruitment			Recruitment			Recruitment			
Fielding	10/5/84	355 days		9/25/85	332 days		9/2/86	325 days		7/24/87	341 days		7/15/88
Estimate	N/A		66.8%	267	165	54.2%	322	36	62.2%	216	238	88.6%	continued
SE			12.5%	69	73	6.3%	56	33	6.0%	22	48	11.6%	next
CV				25.8%			17.4%			10.2%			line
Fielding	7/15/88	345 days		6/27/89[a]									
Estimate	411	118	55.6%	332									
SE	63	42	11.2%	68									
CV	15.3%			19.9%									
Tolsona	10/2/86	237 days		6/3/87	353 days		5/26/88	96 days		9/01/88	267 days		5/24/89
Estimate	1,901	138	55.9%	1,205	98	71.1%	1,454	451	66.5%	1,005	600	63.6%	1,092
SE	120	209	4.2%	116	159	6.8%	164	97	8.5%	131	127	9.7%	148
CV	6.3%			9.6%			11.4%			13.1%			13.6%
Paxson	7/10/86	365 days		7/10/87	336 days		6/26/88						
Estimate	9,111	1,787	53.9%	3,883	-29	62.6%	2,402						
SE	1,996	1,392	6.8%	577	318	13.8%	539						
CV	21.6%			14.9%			22.4%						
Louise	6/27/86	381 days		7/13/87	330 days		6/16/88						
Estimate	6,990	1,864	35.2%	5,978	538	49.5%	3,458						
SE	2,131	2,032	11.9%	1,896	962	11.3%	904						
CV	30.5%			31.7%			26.1%						
Round[b] Tangle	8/05/86	370 days		8/10/87	312 days		6/18/88	373 days		6/26/89			
Estimate	1,241		37.6%	774	370	35.2%	642	529	35.2%	755			
SE	379		12.2%	311	188	12.7%	243	281	12.7%	358			
CV	30.5%			40.2%			37.9%			47.4%			

[a] Duration between the middle of sampling events or group of sampling events.

[b] Statistics for the population in Round Tangle Lake are for burbot larger than 299 mm TL.

Table 5. Possible extremes in estimates of survival rates, recruitment, and abundance for fully recruited burbot (≥ 450 mm TL) in mark-recapture experiments compromised through tag loss and uncertainty of secondary marks.

	Date and[a] Abundance	Recruitment	Survival Rate	Date and Abundance	Recruitment	Survival Rate	Date and Abundance	Recruitment	Survival Rate	Date and Abundance
		——337 days——		5/24/88	——113 days——		9/16/88	——247 days——		5/21/89
	Lower Estimate	1,732	48.9%	2,884	-312	50.7%	1,150	696	73.8%	1,544 continued
MOOSE	6/24/87	342	9.0%	403	203	6.0%	138	138	9.2%	185 below
Estimate	2,357			14.0%			12.0%			12.0%
SE	448									
CV	5.2%									
	Upper Estimate	1,909	53.8%	3,178	-266	45.7%	1,185	697	74.8%	1,582 continued
		385	10.2%	461	201	5.6%	147	146	9.3%	193 below
				14.5%			12.4%			12.2%
MOOSE	5/21/89	——50 days——		7/10/89	——67 days——		9/15/89			
	Lower Estimate	30	63.8%	1,016	79	57.9%	668			
		111	10.2%	170	66	12.1%	119			
				16.7%			17.8%			
	Upper Estimate	6	63.8%	1,016	79	57.9%	668			
		113	10.3%	170	66	12.1%	119			
				16.7%			16.7%			
		—— 31 days——		7/7/87	——408 days——		8/26/88			
	Lower Estimate	637	57.9%	2,092		51.5%	1,711			
HUDSON	6/7/87	481	17.5%	747		22.2%	766			
Estimate	3,671[a]			35.7%			44.8%			
SE	705									
CV	19.2%									
	Upper Estimate	1,237	54.8%	1,982		51.1%	2,249			
		767	18.4%	762		22.8%	1,071			
				38.4%			47.6%			

[a] Estimates for 1987 were obtained from Parker et al. (1988).

the abundance estimates of fully recruited burbot decreased from 1,582 to 668 with coefficients of variation increasing from 12.2% to 17.8%. During the period from 1987 to 1988, the upper and lower estimates of burbot abundance in Hudson Lake averaged 2,009 fully recruited burbot (cv's ranged from 35.7% to 44.8%).

Survival and Recruitment Rates

The estimated rates of annual survival were relatively stable for populations in Fielding, Tolsona, and Paxson lakes, averaging about 65% (Table 4). All of the estimated rates of annual survival from Lake Louise and Round Tangle Lake were below 50%. The standard errors for all the estimated rates of annual survival were below 15%. The lower and upper estimates of annual survival rates for fully recruited burbot ranged from 51% to 55%, respectively, in Hudson Lake, and 49% to 75%, respectively, in Moose Lake. Estimates of annual mortality rates and associated standard errors are presented in Appendices B8-B9.

Estimates of annual recruitment of fully recruited burbot in Lake Louise and Paxson Lake ranged from 538 to 0 during 1987-1988 (Table 4). Estimates of annual recruitment of fully recruited burbot in Fielding, Tolsona, and Round Tangle lakes ranged from 118 to 600 during 1988-1989. The standard errors of recruitment for Lake Louise, Tolsona, and Paxson lakes are larger than the estimates of recruitment.

Abundance estimates of fully recruited burbot in Moose and Hudson lakes indicate some natural mortality occurs between the summer sampling events. Estimates of abundance and mean CPUE drop between these summer sampling events in both lakes (Table 5 and 6). The abundance estimates of fully recruited burbot in Moose Lake decrease over time and are significantly different. The survival estimates are not significantly different over the same time period in Moose Lake. This similar change in burbot abundance was detected in Hudson Lake during the summer sampling in 1987.

Density

The density of fully recruited burbot varied from 0.5 burbot per hectare in Lake Louise to 14.5 burbot per hectare in Moose Lake (Table 7). The density of partially recruited burbot varied from 2.2 burbot per hectare in Fielding Lake to 10.4 burbot in Sevenmile Lake (Table 7). In general, the deeper and larger lakes contained less dense populations of fully and partially recruited burbot.

Mean CPUE

Frequencies of sets by depth and average catch by depth for fully and partially recruited burbot for selected lakes sampled during 1989 are presented in Appendices C1-C12. For Lake Louise and Fielding, George, Harding, Hudson, Jack, Moose, Paxson, Summit, Susitna, T, Tolsona, and Tyone lakes, mean CPUE was calculated independently for fully and partially recruited burbot. Mean CPUE of fully recruited burbot in these lakes ranged from 7.11 burbot per set in Moose Lake during mid-May to 0.12 burbot per set

Table 6. Estimated mean CPUE of burbot fully recruited (≥ 450 mm TL) to the sampling gear from stratified and unstratified systematic sampling events in most[a] populations studied in 1989.

Lakes and Dates	Strata	Number of Sets and Transects		Mean CPUE Unbiased	Mean CPUE Biased[b]	%D	SE	CV
Fielding								
6/26-30	All depths	180	32	0.80	0.70	-13.0%	0.11	16.9%
9/22-26	All depths	239	42	0.26	0.25	-4.4%	0.05	23.0%
George								
6/01-11	All depths	298	37	0.98	0.92	-6.4%	0.09	10.8%
Harding								
9/18-22	All depths	120	11	0.43	0.39	-7.9%	0.11	29.8%
Hudson								
7/11-18	All depths	241	23	0.94	0.97	3.9%	0.13	12.8%
Jack								
7/19-22	All depths	120	22	0.83	0.81	-2.4%	0.13	16.0%
Louise								
6/1-17	<15 meters	1,498	86	0.42	0.39	-4.1%	0.03	9.0%
Moose								
5/24	All depths	62	10	7.11	6.85	-3.7%	0.75	10.9%
7/12	All depths	61	11	2.75	2.48	-9.9%	0.62	25.1%
9/07	All depths	60	10	2.83	2.88	1.8%	0.48	16.8%
10/6	All depths	61	13	2.45	2.56	4.5%	0.63	24.4%
Paxson								
9/15-25	<15 meters	592	102	0.46	0.39	-16.1%	0.05	11.9%
Summit								
7/14-17	All depths	119	22	0.21	0.20	-6.2%	0.06	32.6%
Susitna								
6/15-7/1	<15 meters	1,396	111	0.25	0.21	-20.7%	0.03	12.3%

-Continued-

Table 6. (Page 2 of 2).

Lakes and Dates	Strata	Number of Sets and Transects		Mean CPUE Unbiased	Mean CPUE Biased[b]	%D	SE	CV
T								
5/17-21	All depths	80	10	0.71	0.71	0.4%	0.16	23.1%
8/17-22	All depths	120	13	0.12	0.14	19.8%	0.16	55.8%
Tolsona								
5/23-25	All depths	61	11	5.86	5.58	-4.9%	0.81	14.5%
9/12-14	All depths	61	11	4.08	3.87	-5.1%	0.50	12.9%
Tyone								
6/30-7/3	All depths	202	37	0.79	0.73	-8.4%	0.10	14.8%

[a] To reduce burbot kills from decompression of deep water sets several of the lakes were stratified by depth.

[b] Calculation based on arithmetic means even though they may be slightly biased.

Table 7. Estimated density of burbot in 11 lakes in interior Alaska during 1989.

Fully Recruited[a]			Partially Recruited		
Lake	Number per ha	SE	Lake	Number per ha	SE
Moose	14.5	2.1			
Tolsona	23.0	5.0			
Paxson	3.9	1.0			
Fielding	0.7	0.1		2.2	4.1
Louise[b]	0.5	0.1			
			Landlock Tangle[c]	4.5	1.9
			Round Tangle[c]	6.3	2.0
			Upper Tangle[c]	6.2	2.1
			Shallow Tangle[c]	2.2	1.2
T	0.6	0.1			
			Sevenmile	10.4	5.5

[a] For all populations, burbot ≥ 450 mm TL were considered fully recruited to the gear while smaller fish were considered to be partially recruited.
[b] Density estimates are for the year 1988.
[c] Partially and fully recruited burbot were combined.

in T Lake during late August (Table 6). Mean CPUE for partially recruited burbot in these lakes ranged from 1.83 and 1.74 in Tolsona and Moose lakes, respectively, to 0.03 in George Lake (Table 8).

The highest mean CPUE for all Tangle lakes was 1.35 during the first event in Round Tangle Lake and the lowest mean CPUE was 0.22 during the first event in Shallow Tangle Lake during 1989 (Table 9). Frequency of sets and average catch per set by depth for all burbot are in Appendices C12-C15 for Landlock, Round, Shallow, Upper Tangle, and Sevenmile lakes in 1989.

Of those populations sampled more than once during 1989, only in Sevenmile Lake did the second sampling event have a higher mean CPUE than during the first sampling event (Table 9). Moose Lake was sampled four times during 1989; the first sampling event had the highest mean CPUE at 7.11 for fully recruited burbot. The remaining sampling events in Moose Lake exhibited relatively stable mean CPUE's: 2.75, 2.83, and 2.45 (Table 6). This trend in mean CPUE was also evident in partially recruited burbot (Table 9).

Age, Length, and Weight

Mean length of fully and partially recruited burbot varied among lakes and among sampling events in lakes (Table 10). George Lake contained the largest burbot fully recruited to the gear over a given event (654 mm TL) with populations in T Lake and Lake Louise containing the next largest (602 mm and 586 mm TL, respectively). Upper Tangle Lake contained the smallest population of the fully recruited burbot (471 mm TL). All the estimates of mean lengths of fully recruited burbot based on large sample sizes were similar between sampling events in the same lake except for the populations in lakes of the Tangle Lake complex. There were no fully recruited burbot captured in Sevenmile Lake during two sampling events of 1989. During the first sampling event in Shallow Tangle Lake, fully recruited burbot were captured, but not during the second sampling event. The mean length decreased between events in the remaining Tangle lakes.

During 1989, only Landlock Tangle and Hudson lakes had significant sampling mortality to warrant reporting mean length-at-age (Table 11). Recognition of the sex of burbot by inspection of their gonads proved quite difficult. However, field personnel conducting autopsies were trained to identify subtle differences in underdeveloped gonads.

In all the burbot populations studied in 1989, the samples of larger burbot were very limited. The limited length-weight data obtained were added to the existing length-weight database and growth parameters were estimated. Unfortunately, there were no significant improvements over the relative precision of previously published estimates of length-weight relationships for lake burbot populations (Parker et al. 1987 and 1988). To improve the previously published length-weight parameter estimates (Parker et al. 1987 and 1988) of lake burbot, sample sizes of larger burbot (> 600 mm TL) need to be increased.

Due to limited burbot abundance in many of the study lakes, adequate sample sizes to determine age related statistics becomes an issue of conservation. All sampling mortalities are dissected for age structure (otolith); for those

Table 8. Estimated mean CPUE of burbot partially recruited to the sampling gear (<450 mm TL) from stratified and unstratified systematic sampling events in most populations studied in 1989.

Lakes and Dates	Strata	Number of Sets and Transects		Mean CPUE Unbiased	Mean CPUE Biased[b]	Mean CPUE %Δ	SE	CV
Fielding								
6/26-30	All depths	180	32	1.02	0.85	-16.9%	0.14	17.5%
9/22-26	All depths	239	42	0.45	0.44	-2.2%	0.07	16.7%
George								
6/01-11	All depths	298	37	0.03	0.03	0.4%	0.01	43.3%
Harding								
9/18-22	All depths	120	11	0.60	0.55	-8.8%	0.11	21.4%
Hudson								
7/11-18	All depths	241	23	0.15	0.15	-1.1%	0.05	30.3%
Jack								
7/19-22	All depths	120	22	0.78	0.80	2.1%	0.16	20.9%
Louise[a]								
6/1-17	<17 meters	1,498	88	0.08	0.09	11.1%	0.03	33.5%
Moose								
5/24	All depths	10	62	1.74	1.92	10.3%	0.60	31.3%
7/12	All depths	11	61	0.60	0.55	-8.3%	0.14	25.1%
9/07	All depths	10	60	1.01	1.01	-0.5%	0.28	27.9%
10/6	All depths	13	61	1.13	1.22	8.0%	0.59	47.9%
Paxson[c]								
9/15-25	<17 meters	592	102	0.23	0.24	5.9%	0.04	14.4%
Summit								
7/14-17	All depths	119	22	0.06	0.05	-16.3%	0.03	67.4%
Susitna[a]								
6/15-7/1	<17 meters	1,396	111	0.17	0.18	0.9%	0.03	16.5%

-Continued-

Table 8. (Page 2 of 2).

Lakes and Dates	Strata	Number of Sets	Number of Transects	Mean CPUE Unbiased	Mean CPUE Biased[b]	%Δ	SE	CV
T								
5/17-21	All depths	80	10	0.26	0.25	-1.6%	0.10	40.5%
8/17-21	All depths	120	13	0.07	0.08	12.5%	0.05	53.0%
Tolsona								
5/24	All depths	61	11	1.83	2.10	14.9%	0.59	27.8%
9/13	All depths	61	11	1.03	1.04	1.2%	0.20	19.2%
Tyone								
6/30-7/3	All depths	192	32	0.16	0.16	4.1%	0.05	32.0%

[a] Estimates of mean CPUE are probably biased because sampling was restricted to depths ≤ 17 m at a time when partially recruited burbot are in deeper water (Parker et al. 1989).

[b] Calculation based on arithmetic means even though they may be slightly biased.

[c] Estimates of mean CPUE are probably not biased by sampling at depths ≤ 17 m, because burbot of this size are evenly distributed across all depths in this lake during the sampling period (Parker et al. 1989).

Table 9. Estimated mean CPUE of all burbot from stratified and unstratified systematic sampling events in populations studied during 1989 from Landlock Tangle, Round Tangle, Sevenmile, Shallow Tangle, and Upper Tangle lakes.

Lakes and Dates	Strata	Number of Sets and Transects		Mean CPUE Unbiased	Mean CPUE Biased[a]	Mean CPUE %Δ	SE	CV
Landlock Tangle								
7/9-13	All depths	179	23	0.43	0.38	-11.1%	0.08	21.5%
8/7-11	All depths	179	30	0.40	0.40	-0.9%	0.08	22.1%
Round Tangle								
6/24-27	All depths	120	16	1.35	1.09	-18.8%	0.22	20.8%
7/25-28	All depths	117	15	0.58	0.64	10.2%	0.18	29.2%
Sevenmile								
6/29-7/1	All depths	40	7	0.52	0.46	-11.1%	0.22	47.9%
8/3-5	All depths	40	7	0.77	0.80	4.1%	0.30	38.1%
Shallow Tangle								
6/22-25	All depths	118	27	0.22	0.22	-3.1%	0.06	30.6%
7/23-26	All depths	115	25	0.25	0.29	15.6%	0.08	29.4%
Upper Tangle								
7/7-10	All depths	118	25	0.50	0.46	-8.0%	0.12	26.9%
8/5-8	All depths	118	25	0.32	0.34	6.2%	0.12	36.9%

[a] Calculation based on arithmetic means even though they may be slightly biased.

Table 10. Mean lengths (mm TL) of burbot measured during sampling events in 18 lakes in interior Alaska in 1989.

		First Event			Second Event			Both Events
		Recruitment to the gear			Recruitment to the gear			
Lake	Statistic	Part.	Fully[a]	All	Part.	Fully[a]	All	Fully
Fielding	Mean	395	512	446	383	515	433	513
	SE	3	6	4	4	7	6	4
	Samples	183	140	323	105	64	169	492
George	Mean	401	654	642				
	SE	10	6	6				
	Samples	10	294	304				
Harding	Mean	398	534	457				
	SE	4	9	8				
	Samples	70	54	124				
Jack	Mean	394	510	454				
	SE	4	6	6				
	Samples	93	99	192				
Paxson	Mean	359	581	507				
	SE	5	5	6				
	Samples	139	278	417				
Sevenmile	Mean	333		333	325		325	
	SE	6		6	2		2	
	Samples	21		21	31		31	
Shallow Tangle	Mean	375	543	406	354		354	543
	SE	9	38	16	7		7	38
	Samples	22	5	27	30		30	5
Summit	Mean	390	534	501				
	SE	13	14	15				
	Samples	8	27	35				
T	Mean	375	602	533	391	585	512	598
	SE	9	15	17	15	28	26	13
	Samples	21	48	69	9	15	24	63

- Continued -

Table 10. (Page 2 of 2).

Lake	Statistic	First Event: Recruitment to the gear Part.	First Event: Recruitment to the gear Fully[a]	First Event: Recruitment to the gear All	Second Event: Recruitment to the gear Part.	Second Event: Recruitment to the gear Fully[a]	Second Event: Recruitment to the gear All	Both Events: Fully
Upper Tangle	Mean	386	523	417	363	491	390	511
	SE	6	21	10	8	15	11	14
	Samples	45	13	58	30	8	38	21
Round Tangle	Mean	374	533	390	371	471	375	524
	SE	3	22	5	4	3	5	19
	Samples	146	16	162	65	3	68	19
Landlock Tangle	Mean	363	528	390	360	492	392	507
	SE	5	21	9	5	14	8	12
	Samples	66	13	79	56	18	74	31
Louise	Mean	375	586	550				
	SE	5	3	4				
	Samples	122	607	729				
Hudson	Mean	406	573	548				
	SE	6	6	6				
	Samples	39	225	264				
	5/21-23				7/10-12			
Moose	Mean	402	524	400	393	520	496	
	SE	3	2	3	7	2	4	
	Samples	109	442	551	37	163	200	
	9/15-17				10/4-6			All
	Mean	389	515	482	396	521	482	493
	SE	5	3	4	4	3	5	6
	Samples	61	170	231	68	151	219	1,201
Susitna	Mean	368	559	485				
	SE	4	5	5				
	Samples	234	367	601				
Tolsona	Mean	405	514	488	401	522	498	492
	SE	3	2	3	5	3	4	5
	Samples	114	364	478	62	249	311	789
Tyone	Mean	422	518	502				
	SE	5	7	6				
	Samples	31	159	190				

[a] Burbot partially recruited to the gear are <450 mm TL and fully recruited burbot are ≥450 mm TL.

Table 11. Estimated mean length-at-age for burbot sampled from Landlock Tangle and Hudson lakes in 1989.

Landlock Tangle Lake		Age														
Sex	Statistic	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Male	Sample Size	0	4	3	4	0	1	0	0	0	1	0	0	0	0	0
	Mean Length		323	284	317		412				510					
	S.E.		14	31	10		0				0					
Female	Sample Size		5	4	3	2	0	0	0	0	0	0	0	0	0	0
	Mean Length		411	356	371	417										
	S.E.		12	21	12	20										
Combined																
	Sample Size	3	9	7	7	2	1	0	0	0	1	0	0	0	0	0
	Mean Length	304	325	337	352	417	412				510					
	S.E.	15	13	26	9	16	0				0					
Hudson Lake																
Male	Sample Size	0	0	1	0	1	2	1	1	1	0	1	0	0	0	0
	Mean Length			435		550	595	615	665	695		750				
	S.E.						3									
Female	Sample Size	0	0	2	1	4	4	4	3	5	4	3	1	0	0	0
	Mean Length			455	515	554	587	619	650	683	726	745	770			
	S.E.			27	0	31	39	19	20	28	31	38	0			
Combined																
	Sample Size	0	0	3	1	5	6	5	4	6	4	4	1	0	0	0
	Mean Length			442	515	553	588	618	658	691	726	746	770			
	S.E.			25	0	28	31	18	20	28	31	37	0			

lakes that have sampling mortalities greater than 20 burbot, mean length at age was calculated (Table 11). Obtaining age data on a opportunistic basis will take years to develop adequate sample sizes to determine age-length parameters.

DISCUSSION

The accuracy of abundance estimates from the mark-recapture experiments is predicated on certain conditions (Ricker 1975): (1) equal probability of capture for all burbot during at least one sampling event or complete dispersal of tagged burbot throughout the population, (2) ability to identify marked fish, (3) no recruitment between sampling events, and (4) equal probability of survival and capture of marked and unmarked fish. During all the sampling events, sampling effort and tagged burbot were spread throughout each lake. Monitoring the depths of burbot between sampling events separated by a month or more confirmed that random mixing of tagged burbot occurred throughout the water column. The change in depths of tagged burbot between sampling events combined with catches of tagged and untagged burbot throughout the study lakes indicates that tagged burbot are mixing with untagged burbot between sampling events. Separating burbot by size (< 450 and ≥ 450 mm TL) relieves problems of gear selectivity for burbot of different sizes (Parker et al. 1987 and 1988). As for the second condition, there was no evidence of fin regeneration even though some tag loss was recorded. Regarding the third condition, the duration between sampling events for some study lakes was often only a few weeks, allowing little time for growth recruitment to occur. When growth recruitment could occur, the methods of Robson and Flick (1965) were applied to detect growth recruitment between sampling events. As for the fourth condition of equal probability of survival and capture of marked and unmarked fish, some of the burbot which were caught at depths greater than 17 m exhibited varying degrees of decompression (extended gas bladder). Unfortunately, these sampling injuries were not recorded for individually tagged burbot to document their subsequent survival. Those burbot exhibiting gross signs of decompression were sacrificed while those with milder symptoms were tagged, marked, and released. Further analysis of recaptures across depths to evaluate survival from deep water sampling is in progress.

Several of the lakes studied since 1986 have exhibited declines in the abundance of fully recruited burbot with Lake Louise and Paxson Lake having the most dramatic declines. Lake Louise supported an expanding fishery from 1977 through 1986, with a peak harvest of 3,200 burbot during 1986 (Mills 1989). The abundance of fully recruited burbot during 1986 was estimated to be about 7,000 burbot. By 1988, the estimated abundance of burbot had fallen to only 3,000 adult burbot, less than the estimated harvest of burbot during 1986. The abundance of fully recruited burbot has also declined dramatically in Paxson Lake, from about 9,000 burbot in 1986 to only 2,500 in 1989. The estimates of mean CPUE for fully recruited burbot for both Paxson Lake and Lake Louise have also decreased from 1986 to 1989. In addition, the mean lengths of fully recruited burbot captured between 1988 and 1989 in these lakes have increased, suggesting that few sub-adult burbot have recruited into these populations. These three independent methods of burbot stock assessment indicate that both Paxson Lake and Lake Louise burbot stocks are depressed.

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Appendix A: Description of Lakes

FIELDING LAKE (63#10' N, 145#42' W) is accessible by road 3 km southwest of the Richardson Highway. Fielding Lake is 538 ha with a maximum depth of 24 m and an elevation of 906 m. Campground facilities and a lodge operated during the summer are located at the mouth of the outlet, and 15 to 20 recreational cabins are located along the south shore. Fielding Lake contains Arctic grayling, lake trout *Salvelinus namaycush*, round whitefish *Prosopium cylindraceum*, and burbot.

GEORGE LAKE (63#47'N, 144#31' W) is located approximately 72 km southeast of Delta Junction across the Tanana River. George Lake is accessible by plane or boat in the summer months and by snowmachine during a limited time when the Tanana River is frozen (February 1 - April 15). The lake is 1,863 ha with a maximum depth of 11 m and an elevation of 389 m. There are only two private recreational cabins on George Lake. The Dot Lake Native Corporation (Dot Lake, Alaska) owns most of the shoreline, and permission is required for access for recreational purposes. Sport fishing for northern pike is popular just as the ice leaves the lake in the spring when these fish congregate at the shallow west end of the lake to spawn. George Lake also contains longnose suckers *Catostomus catostomus*, round whitefish, humpback whitefish *Coregonus pidschian*, least cisco *Coregonus sardinella*, burbot, and Arctic grayling.

HARDING LAKE (64#25' N, 146#50' W) is accessible by road, located 72 km southeast of Fairbanks along the Richardson Highway. Harding Lake is 1,000 ha with a maximum depth of 47 m and an elevation of 218 m. Campground facilities and a boat launch are located on the west shore of the lake; recreational cabins and houses are located along the shoreline. Indigenous species in Harding Lake are northern pike *Esox lucius*, least cisco, slimy sculpin *Cottus cognatus*, and burbot. Transplanted species include lake trout, rainbow trout *Oncorhynchus mykiss*, Arctic grayling, sheefish *Stenodus leucicthys*, and coho salmon *Oncorhynchus kisutch*.

HUDSON LAKE (61#53' N, 145#40' W) is a remote lake 19 km southwest of Copper Center. Hudson Lake is 259 ha with a maximum depth of 16 m and an elevation of 655 m. Although there are no cabins or public recreational facilities at the lake, there is a large winter ice fishery for burbot. Hudson Lake contains Arctic grayling, round whitefish, longnose suckers, burbot, and rainbow trout.

JACK LAKE (62#31' W, 143#17' W) is located south of the Nabesna road 45 km east of the Glenn Highway. There is a 2.4 km private road available to access the lake. The outlet of Jack Lake drains into the Nabesna River; it is 150 ha with a maximum depth of 30 m and the elevation is 915 m. Jack Lake is within the Wrangell - Saint Elias National Preserve. There are limited recreational facilities on the lake, which consist of a float plane base, fish guiding, and rental cabins. A few private cabins are found along the shores of Jack Lake. Jack Lake receives light to moderate fishing pressure, primarily set line fishing for lake trout and burbot during the ice cover months. Other species present include: grayling, round whitefish, and longnose suckers.

LAKE LOUISE (62#20' N, 146#30' W) is the largest lake in a three-lake system that is accessible by the Glenn Highway on a 25 km gravel road. Lake Louise is 6,519 ha with maximum depth of 51 m and an elevation of 720 m. A state campground with boat launch is available. Four lodges are found along the south end of the lake, and numerous cabins are located around the shore. Lake Louise supports year-round fishing for lake trout, burbot, Arctic grayling, and round whitefish.

LANDLOCK TANGLE LAKE (63#00' N, 146#03' W) is located south of Upper Tangle Lake and is accessible by foot over a 1 km portage. Landlock Tangle Lake is 219 ha with maximum depth of 36 m and an elevation of 875 m. Landlock Tangle Lake has Arctic grayling, lake trout, round whitefish, burbot, and longnose suckers.

MOOSE LAKE (62#07' N, 146#05' W) is accessible from Tolsona Lake by a 1 km trail from the north end of Tolsona Lake. Moose Lake is 130 ha with a maximum depth of 6 m and an elevation of 625 m. There are four cabins located along the lake shore and no public recreational facilities. Moose Lake receives fishing pressure largely during the winter months for burbot. Moose Lake contains burbot, Arctic grayling, longnose suckers, and rainbow trout.

PAXSON LAKE (62#50' N, 145#35' W) is directly accessible from the Richardson Highway 8 km south of Paxson. Paxson Lake is 1,575 ha with a maximum depth of 29 m and an elevation of 778 m. There are numerous cabins along the shore and the Bureau of Land Management maintains a public campground and boat launch. Paxson Lake is the start of a popular float trip on the Gulkana River to Sourdough. This lake is popular for its wide variety of fishing as well as hunting opportunities. Paxson Lake contains lake trout, burbot, sockeye salmon *O. nerka*, Arctic grayling, round whitefish, and other species.

ROUND TANGLE LAKE (63#02' N, 145#48' W) is located north of the Denali Highway. Round Tangle Lake is 155 ha with a maximum depth of 29 m and an elevation of 851 m. A public boat launch, campground facilities and lodge accommodations are available through the spring and fall. During the winter months the Denali Highway is closed and the Tangle lakes receive very little fishing pressure. Round Tangle Lake has Arctic grayling, lake trout, round whitefish, burbot, and longnose suckers.

SEVENMILE Lake (63#06' N, 145#38' W) is located 1 km by road from the Denali Highway. Sevenmile Lake is 34 ha with a maximum depth of 12 m and an elevation of 991 m. A public boat launch and campsites are available at the south end of the lake. Sevenmile Lake contains lake trout and burbot populations. No other species are known to exist in the lake.

SHALLOW TANGLE LAKE (63#02' N, 145#48' W) is located north of Round Tangle Lake. Shallow Tangle Lake is accessible by boat through Round Tangle Lake and a 500 m river between the two lakes. Shallow Tangle Lake is 130 ha with a maximum depth of 24 m and an elevation of 849 m. Shallow Tangle Lake has Arctic grayling, lake trout, round whitefish, burbot, and longnose suckers.

SUMMIT LAKE (63#12' N, 145#33' W) is directly accessible from the Richardson Highway just 6 km north of Paxson. Summit Lake is 1,651 ha with a maximum depth of 72 m and an elevation of 979 m. Public facilities are available for launching boats only. There is one lodge and a private recreational vehicle campground along the lake. Summit Lake contains lake trout, sockeye salmon, burbot, and round whitefish.

SUSITNA LAKE (62#25' N, 146#38' W) is the second lake in a three-lake system and is accessible by a connecting channel of 100 m to Lake Louise. Susitna Lake is 3,816 ha with a maximum depth of 37 m and an elevation of 720 m. There are many private recreational cabins scattered along the shores of Susitna Lake, however, no commercial accommodations are present. Susitna Lake has lake trout, burbot, longnose suckers, and round whitefish.

T LAKE (63#48' N, 143#53' W) is a remote fly-in lake, located approximately 18 km from the village of Dot Lake along the Alaska Highway. T Lake is 162 ha with a maximum depth of 18 m and an elevation of 434 m. Only one permanent recreational structure exists on the lake. T Lake contains northern pike, humpback whitefish, least cisco, and burbot.

TOLSONA LAKE (62#06' N, 146#04' W) is accessible from the Glenn Highway. Tolsona Lake is 130 ha with a maximum depth of 4 m and an elevation of 625 m. Tolsona Lake has numerous cabins and one lodge. No public recreational facilities are available. This lake has had a popular burbot fishery in the winter in recent years. Tolsona Lake has burbot, Arctic grayling, stocked rainbow trout, longnose suckers, and other species.

TYONE LAKE (62#30' N, 146#45' W) is the first lake in a three-lake system and is accessible by a connecting channel of 100 m to Susitna Lake. Tyone Lake is 389 ha with a maximum depth of 9 m and an elevation of 720 m. There are the abandoned remains of an Indian settlement (Tyone Village) and only a handful of private cabins located on this lake. Tyone Lake has Arctic grayling, lake trout, burbot, longnose suckers, and round whitefish.

UPPER TANGLE LAKE (63#00' N, 146#04' W) is located south of the Denali Highway but drains through a 500 m long river into Round Tangle Lake. Upper Tangle Lake is 142 ha with a maximum depth of 30 m and an elevation of 868 m. A boat launch and campground facilities are available at the mouth of this lake. Upper Tangle Lake has Arctic grayling, lake trout, round whitefish, burbot, and longnose suckers.

Appendix B: Appendix Tables

Appendix B1. Mark and recapture histories of burbot by sampling event for 15 lakes studied from 1982 through 1989.

	PAXSON								TOLSONA							
DATE:																
Year	1986	1986	1986	1987	1987	1988	1988	1989	1986	1986	1987	1987	1988	1988	1989	1989
Beginning	7/07	8/04	9/16	7/06	8/06	6/22	7/19	9/13	9/23	10/8	6/2	6/23	5/25	8/30	5/22	9/11
Ending	7/12	8/14	9/20	7/13	8/14	6/30	7/27	9/25	9/27	10/10	6/4	6/25	5/27	9/01	5/24	9/13
NUMBER OF FULLY RECRUITED BURBOT:																
Recaptured from Event 1	0	16	13	32	23	18	3	6	0	131	68	23	26	12	5	2
Recaptured from Event 2	0	0	7	7	9	1	0	2	0	0	19	12	9	2	1	1
Recaptured from Event 3	0	0	0	16	8	8	4	4	0	0	0	64	57	24	26	16
Recaptured from Event 4	0	0	0	0	59	41	21	13	0	0	0	0	23	8	8	2
Recaptured from Event 5	0	0	0	0	0	40	8	9	0	0	0	0	0	51	37	13
Recaptured from Event 6	0	0	0	0	0	0	16	17	0	0	0	0	0	0	47	13
Recaptures from Event 7	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	63
Captured with Tags	0	16	20	55	99	108	52	57	0	138	87	99	115	97	124	110
Captured without Tags	463	96	164	517	238	388	148	221	531	342	307	71	234	109	232	130
Captured	463	112	184	572	337	396	200	278	531	480	394	170	349	206	356	240
Released with Tags	463	111	184	571	335	396	57	278	531	141	394	167	349	206	356	240
NUMBER OF PARTIALLY RECRUITED BURBOT:																
Recaptured from Event 1	0	1	0	1	0	0	1	0	0	7	11	3	0	0	0	0
Recaptured from Event 2	0	0	0	1	0	0	0	1	0	0	2	0	9	2	4	1
Recaptured from Event 3	0	0	0	2	0	0	0	0	0	0	0	11	9	2	11	9
Recaptured from Event 4	0	0	0	0	4	1	7	3	0	0	0	0	0	1	0	0
Recaptured from Event 5	0	0	0	0	0	2	2	0	0	0	0	0	0	1	7	2
Recaptured from Event 6	0	0	0	0	0	0	2	1	0	0	0	0	0	0	1	0
Recaptures from Event 7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Captured with Tags	0	1	0	4	4	3	12	5	0	7	13	14	18	6	23	15
Captured without Tags	85	81	35	167	136	122	139	130	163	106	215	27	116	46	106	55
Captured	85	82	35	171	140	125	151	135	163	113	228	41	134	52	129	70
Released with Tags	50	17	33	157	108	70	12	135	153	9	228	40	133	52	106	55

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	Louise						Susitna						Tyone					
Year	1986	1986	1987	1987	1988	1989	1986	1986	1987	1987	1988	1989	1986	1986	1987	1987	1988	1989
Beginning	6/25	8/19	7/06	8/02	6/11	6/01	6/27	8/13	7/18	8/21	6/11	6/16	6/26	8/11	7/29	8/28	6/09	6/30
Ending	6/28	8/19	7/20	8/19	6/24	6/17	6/29	8/19	7/31	8/30	6/26	7/01	6/28	8/13	8/04	9/01	6/11	7/03
NUMBER OF FULLY RECRUITED BURBOT:																		
Recaptured from Event 1	0	8	5	4	5	3	0	0	0	2	2	2	0	2	2	4	3	2
Recaptured from Event 2	0	0	5	5	4	9	0	0	1	0	2	2	0	0	1	0	2	1
Recaptured from Event 3	0	0	0	10	14	7	0	0	0	1	2	1	0	0	0	3	2	0
Recaptured from Event 4	0	0	0	0	12	10	0	0	0	0	0	1	0	0	0	0	4	1
Recaptured from Event 5	0	0	0	0	0	36	0	0	0	0	0	17	0	0	0	0	0	6
Captured with Tags	0	0	10	19	35	65	0	0	1	3	6	23	0	2	3	7	11	11
Captured without Tags	243	280	303	198	383	597	37	47	117	58	284	324	111	79	73	12	351	143
Captured	243	288	313	217	418	642	37	47	118	61	290	347	111	81	76	19	362	154
Released with Tags	220	258	264	186	368	635	34	43	111	58	266	347	111	71	75	17	358	154
NUMBER OF PARTIALLY RECRUITED BURBOT:																		
Recaptured from Event 1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Recaptured from Event 2	0	0	1	0	0	0	0	0	2	0	0	0	0	0	1	0	1	0
Recaptured from Event 3	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	0	1
Recaptured from Event 4	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Recaptured from Event 5	0	0	0	0	0	4	0	0	0	0	0	6	0	0	0	0	0	1
Captured with Tags	0	0	2	1	2	4	0	0	2	0	1	8	0	0	1	0	1	2
Captured without Tags	79	82	107	58	126	116	43	94	216	165	278	218	20	83	96	59	134	28
Captured	79	82	109	59	128	120	43	94	218	165	279	226	20	83	97	59	135	30
Released with Tags	38	62	72	54	103	120	36	75	200	157	217	226	19	70	97	59	134	30

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Appendix B1. (Page 3 of 8).

	GEORGE				HARDING				
DATE:									
Year	1987	1987	1988	1989	1985	1986	1987	1988	1989
Beginning	6/01	6/22	5/24	6/01	7/22	9/08	6/16	9/26	9/18
Ending	6/11	6/30	5/31	6/11	7/26	9/14	6/20	9/30	9/22
NUMBER OF FULLY RECRUITED BURBOT:									
Recaptured from Event 1	0	8	5	4	0	0	2	0	0
Recaptured from Event 2	0	0	1	1	0	0	14	3	2
Recaptured from Event 3	0	0	0	13	0	0	0	9	4
Recaptured from Event 4					0	0	0	0	8
Captured with Tags	0	8	6	18	0	0	16	12	14
Captured without Tags	166	76	242	276	25	55	87	76	38
Captured	166	84	248	294	25	55	103	88	52
Released with Tags	166	80	248	294	18	54	81	77	52
NUMBER OF PARTIALLY RECRUITED BURBOT:									
Recaptured from Event 1	0	1	0	0	0	0	0	0	0
Recaptured from Event 2	0	0	1	0	0	0	3	1	0
Recaptured from Event 3	0	0	0	0	0	0	0	3	1
Recaptured from Event 4					0	0	0	0	1
Captured with Tags	0	1	1	0	0	0	3	4	2
Captured without Tags	72	17	7	10	35	59	108	76	70
Captured	72	18	8	10	35	59	111	80	72
Released with Tags	72	10	8	10	22	47	80	69	67

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	SUMMIT						T					
DATE:												
Year	1986	1986	1987	1987	1988	1989	1986	1987	1987	1988	1989	1989
Beginning	7/12	8/26	7/13	9/02	7/06	7/14	6/11	5/26	9/21	5/17	5/17	8/17
Ending	7/17	9/04	7/21	9/10	7/11	7/17	6/14	6/01	9/25	5/21	5/21	8/22
NUMBER OF FULLY RECRUITED BURBOT:												
Recaptured from Event 1	0	3	6	2	1	2	0	2	4	0	2	0
Recaptured from Event 2	0	0	2	0	0	0	0	0	14	1	3	0
Recaptured from Event 3	0	0	0	7	8	3	0	0	0	10	7	1
Recaptured from Event 4	0	0	0	0	0	0	0	0	0	0	6	2
Recaptured from Event 5	0	0	0	0	0	2	0	0	0	0	0	7
Captured with Tags	0	3	8	9	9	7	0	2	18	11	18	10
Captured without Tags	52	59	68	54	35	20	13	23	6	8	30	5
Captured	52	62	76	63	44	27	13	25	24	19	48	15
Released with Tags	51	3	74	63	41	27	13	23	24	17	48	14
NUMBER OF PARTIALLY RECRUITED BURBOT:												
Recaptured from Event 1	0	10	3	2	0	0	0	0	0	0	0	0
Recaptured from Event 2	0	0	1	0	0	0	0	0	1	0	1	0
Recaptured from Event 3	0	0	0	3	0	0	0	0	0	1	0	0
Recaptured from Event 4	0	0	0	0	0	0	0	0	0	0	0	0
Recaptured from Event 5	0	0	0	0	0	0	0	0	0	0	0	0
Captured with Tags	0	10	4	5	0	0	0	0	1	1	1	0
Captured without Tags	182	166	65	70	28	8	8	7	3	9	20	9
Captured	182	176	69	75	28	8	8	7	4	10	21	9
Released with Tags	152	10	64	70	19	7	4	8	4	9	21	7

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Appendix B1. (Page 5 of 8).

	ROUND TANGLE							UPPER TANGLE						
DATE:														
Year	1986	1986	1987	1987	1988	1989	1989	1986	1986	1987	1987	1988	1989	1989
Beginning	7/21	8/16	7/27	8/22	6/15	6/24	7/25	7/21	8/18	7/31	8/25	9/09	7/07	8/05
Ending	7/25	8/25	7/30	8/25	6/19	6/27	7/28	7/25	8/20	8/03	8/29	9/22	7/10	8/08
NUMBER OF BURBOT OF ALL SIZES:														
Recaptured from Event 1	0	6	4	1	4	0	0	0	0	0	0	1	1	0
Recaptured from Event 2	0	0	8	0	3	1	0	0	0	4	1	1	0	0
Recaptured from Event 3	0	0	0	5	12	3	1	0	0	0	2	6	2	0
Recaptured from Event 4	0	0	0	0	3	0	1	0	0	0	0	4	2	0
Recaptured from Event 5	0	0	0	0	0	14	3	0	0	0	0	0	3	2
Recaptured from Event 6	0	0	0	0	0	0	10	0	0	0	0	0	0	3
Captured with Tags	0	6	12	6	22	18	15	0	0	4	3	12	8	5
Captured without Tags	155	66	86	51	179	144	53	53	48	41	28	97	50	33
Captured	155	72	98	57	201	162	68	53	48	45	31	109	58	38
Released with Tags	134	63	95	56	193	153	67	48	35	45	31	108	56	37

-Continued-

Appendix B1. (Page 6 of 8).

	SEVENMILE								SHALLOW TANGLE						
DATE:															
Year	1986	1986	1987	1987	1988	1988	1989	1989	1986	1986	1987	1987	1988	1989	1989
Beginning	7/22	9/17	6/16	7/31	6/19	7/17	6/29	8/03	7/21	8/16	7/28	8/24	6/13	6/22	7/23
Ending	8/09	9/21	6/20	8/06	6/21	7/19	7/01	8/05	7/25	8/18	8/01	8/30	6/16	6/25	7/26
NUMBER OF BURBOT OF ALL SIZES:															
Recaptured from Event 1	0	10	5	5	0	1	0	0	0	1	0	0	1	0	0
Recaptured from Event 2	0	0	16	25	4	0	2	0	0	0	0	0	0	0	0
Recaptured from Event 3	0	0	0	8	3	0	2	0	0	0	0	1	2	0	0
Recaptured from Event 4	0	0	0	0	3	3	0	0	0	0	0	0	0	0	0
Recaptured from Event 5	0	0	0	0	0	9	2	0	0	0	0	0	0	1	0
Recaptured from Event 6	0	0	0	0	0	0	2	5	0	0	0	0	0	0	2
Recaptured from Event 7	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Captured with Tags	0	10	21	38	10	13	8	6	0	1	0	1	3	1	2
Captured without Tags	116	82	56	102	20	21	13	25	84	31	49	30	44	26	28
Captured	116	92	77	140	30	34	21	31	84	32	49	31	47	27	30
Released with Tags	36	68	59	105	30	34	21	31	52	1	46	20	47	27	29

-Continued-

Appendix B1. (Page 7 of 8).

	LANDLOCK TANGLE				
DATE:					
Year	1986	1987	1987	1989	1989
Beginning	7/20	6/30	8/02	7/09	8/07
Ending	7/24	7/06	8/07	7/13	8/11
NUMBER OF BURBOT OF ALL SIZES:					
Recaptured from Event 1	0	2	3	0	0
Recaptured from Event 2	0	0	4	5	0
Recaptured from Event 3	0	0	0	2	0
Recaptured from Event 4	0	0	0	0	3
Captured with Tags	0	2	7	7	3
Captured without Tags	50	121	97	72	71
Captured	50	123	104	79	74
Released with Tags	54	109	102	51	71

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Appendix B1. (Page 8 of 8).

FIELDING

DATE:														
Year	1982	1984	1984	1985	1985	1985	1986	1986	1987	1987	1988	1988	1989	1989
Beginning	9/29	7/20	10/1	7/16	8/19	9/23	7/28	8/21	7/21	8/17	6/29	7/27	6/26	7/30
Ending	10/1	7/20	10/8	7/20	8/26	9/27	8/01	8/25	7/27	8/22	7/02	7/31	6/30	8/4
NUMBER OF FULLY RECRUITED BURBOT:														
Recaptured from Event 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Recaptured from Event 2	0	0	0	0	0	0	1	0	1	0	0	0	0	0
Recaptured from Event 3	0	0	0	1	10	2	1	0	1	0	0	0	2	0
Recaptured from Event 4	0	0	0	0	9	4	4	2	1	6	0	0	0	0
Recaptured from Event 5	0	0	0	0	0	11	11	4	9	1	1	0	1	0
Recaptured from Event 6	0	0	0	0	0	0	4	2	6	0	0	0	0	0
Recaptured from Event 7	0	0	0	0	0	0	0	13	13	4	2	0	1	0
Recaptured from Event 8	0	0	0	0	0	0	0	0	9	4	5	1	1	0
Recaptured from Event 9	0	0	0	0	0	0	0	0	0	34	20	5	8	3
Recaptured from Event 10	0	0	0	0	0	0	0	0	0	0	19	4	6	1
Recaptured from Event 11	0	0	0	0	0	0	0	0	0	0	0	21	22	9
Recaptured from Event 12	0	0	0	0	0	0	0	0	0	0	0	0	12	0
Recaptured from Event 13	0	0	0	0	0	0	0	0	0	0	0	0	0	23
Captured with Tags	0	0	0	1	19	17	17	21	40	48	47	31	53	36
Captured without Tags	2	2	41	45	78	26	45	28	67	33	94	24	87	28
Captured	2	2	41	46	97	43	62	49	107	81	141	55	140	64
Released with Tags	1	2	41	47	96	20	59	30	105	55	139	31	136	64
NUMBER OF PARTIALLY RECRUITED BURBOT:														
Recaptured from Event 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Recaptured from Event 2	0	0	0	1	0	0	2	0	0	0	0	0	0	0
Recaptured from Event 3	0	0	0	7	10	1	1	3	0	0	0	1	0	0
Recaptured from Event 4	0	0	0	0	12	3	5	1	1	3	1	0	0	1
Recaptured from Event 5	0	0	0	0	0	16	25	13	7	8	1	1	3	0
Recaptured from Event 6	0	0	0	0	0	0	3	3	4	0	1	0	0	0
Recaptured from Event 7	0	0	0	0	0	0	0	20	11	9	7	3	2	0
Recaptured from Event 8	0	0	0	0	0	0	0	0	8	1	2	1	0	0
Recaptured from Event 9	0	0	0	0	0	0	0	0	0	12	15	3	3	1
Recaptured from Event 10	0	0	0	0	0	0	0	0	0	0	7	3	1	0
Recaptured from Event 11	0	0	0	0	0	0	0	0	0	0	0	10	20	4
Recaptured from Event 12	0	0	0	0	0	0	0	0	0	0	0	0	4	3
Recaptured from Event 13	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Captured with Tags	0	0	0	8	22	20	36	40	31	33	34	22	33	24
Captured without Tags	5	3	62	104	250	47	176	90	101	117	101	64	148	81
Captured	5	3	62	112	272	67	204	130	132	150	135	86	181	105
Released with Tags	5	3	62	111	272	21	189	44	131	32	130	22	174	105

Appendix B2. Mark and recapture history of fully recruited[a] burbot by year for the populations in Fielding, Paxson, Tyone, Susitna, Summit, T, and Harding lakes, Lake Louise, George, and Tolsona lakes.

FIELDING LAKE

DATE: Year	1984	1985	1986	1987	1988	1989
Beginning	7/20	7/16	7/28	7/21	6/29	6/26
Ending	10/8	9/27	8/25	8/22	7/31	8/4
NUMBER OF FULLY RECRUITED BURBOT:[a]						
Recaptured from Event 1	0	13	2	2	0	2
Recaptured from Event 2		0	27	23	1	1
Recaptured from Event 3			0	30	8	2
Recaptured from Event 4				0	48	18
Recaptured from Event 5					0	43
Captured with Tags	0	13	29	55	57	66
Captured without Tags	43	149	90	93	118	115
Captured	43	162	119	148	175	181
Released with Tags	43	138	76	126	149	177

PAXSON LAKE

DATE: Year	1986	1987	1988	1989
Beginning	7/07	7/06	6/22	9/15
Ending	9/20	8/14	7/27	9/25
NUMBER OF FULLY RECRUITED BURBOT:				
Recaptured from Event 1	0	95	34	12
Recaptured from Event 2		0	110	22
Recaptured from Event 3			0	23
Captured with Tags	0	95	144	57
Captured without Tags	759	814	309	221
Captured	759	909	453	278
Released with Tags	759	909	439	278

TYONE LAKE

DATE: Year	1986	1987	1988	1989
Beginning	6/26	7/29	6/09	6/30
Ending	8/13	9/05	6/11	7/03
NUMBER OF FULLY RECRUITED BURBOT:				
Recaptured from Event 1	0	6	5	4
Recaptured from Event 2		0	4	0
Recaptured from Event 3			0	5
Captured with Tags	0	6	9	9
Captured without Tags	182	157	351	156
Captured	182	163	360	165
Released with Tags	182	163	356	165

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SUSITNA LAKE				
DATE: Year	1986	1987	1988	1989
Beginning	6/27	7/18	6/11	6/16
Ending	8/19	8/30	6/26	7/01
NUMBER OF FULLY RECRUITED BURBOT:				
Recaptured from Event 1	0	3	3	4
Recaptured from Event 2		0	3	2
Recaptured from Event 3			0	17
Captured with Tags	0	3	6	23
Captured without Tags	84	176	284	324
Captured	84	179	290	347
Released with Tags	77	169	266	347

SUMMIT LAKE				
DATE: Year	1986	1987	1988	1989
Beginning	7/12	7/13	7/06	7/14
Ending	9/04	9/20	7/11	7/17
NUMBER OF FULLY RECRUITED BURBOT:				
Recaptured from Event 1	0	10	1	2
Recaptured from Event 2		0	8	3
Recaptured from Event 3			0	2
Captured with Tags	0	10	9	7
Captured without Tags	111	122	35	20
Captured	111	132	44	27
Released with Tags	51	130	41	27

T LAKE						
DATE: Year	1986	1987	1987	1988	1989	1989
Beginning	6/11	5/26	9/21	5/17	5/17	8/17
Ending	6/19	6/01	9/25	5/21	5/21	8/22
NUMBER OF FULLY RECRUITED BURBOT:						
Recaptured from Event 1	0	2	4	0	2	0
Recaptured from Event 2		0	14	1	3	0
Recaptured from Event 3			0	10	7	1
Recaptured from Event 4				0	6	2
Recaptured from Event 5					0	7
Captured with Tags	0	2	18	11	18	10
Captured without Tags	13	23	6	8	30	5
Captured	13	25	24	19	48	15
Released with Tags	13	23	24	17	48	14

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HARDING LAKE					
DATE: Year	1985	1986	1987	1988	1989
Beginning	6/25	7/06	6/11	9/26	9/18
Ending	9/02	8/19	6/24	9/30	9/22
NUMBER OF FULLY RECRUITED BURBOT:					
Recaptured from Event 1	0	0	2	0	0
Recaptured from Event 2		0	14	3	2
Recaptured from Event 3			0	9	4
Recaptured from Event 4				0	8
Captured with Tags	0	0	16	12	14
Captured without Tags	25	55	87	76	38
Captured	25	55	103	88	52
Released with Tags	18	54	81	77	52

LAKE LOUISE				
DATE: Year	1986	1987	1988	1989
Beginning	6/25	7/06	6/11	6/01
Ending	9/02	8/19	6/24	6/16
NUMBER OF FULLY RECRUITED BURBOT:				
Recaptured from Event 1	0	19	9	12
Recaptured from Event 2		0	26	17
Recaptured from Event 3			0	36
Captured with Tags	0	19	35	65
Captured without Tags	523	501	348	577
Captured	523	520	383	642
Released with Tags	470	440	368	635

GEORGE LAKE			
DATE: Year	1987	1988	1989
Beginning	6/1	5/24	6/1
Ending	6/30	5/31	6/11
NUMBER OF FULLY RECRUITED BURBOT:			
Recaptured from Event 1	0	6	5
Recaptured from Event 2		0	13
Captured with Tags	0	6	18
Captured without Tags	200	242	276
Captured	200	248	294
Released with Tags	196	248	294

-Continued-

Appendix B2. (Page 4 of 4).

TOLSONA LAKE						
DATE: Year	1986	1987	1988	1988	1989	1989
Beginning	9/23	6/02	5/25	8/30	5/23	9/12
Ending	10/10	6/04	5/27	9/01	5/25	9/14
NUMBER OF FULLY RECRUITED BURBOT:						
Recaptured from Event 1	0	123	35	14	5	3
Recaptured from Event 2	0	0	79	32	33	18
Recaptured from Event 3	0	0	0	51	36	13
Recaptured from Event 4	0	0	0	0	45	13
Recaptured from Event 5	0	0	0	0	0	63
Captured with Tags	0	123	114	97	119	110
Captured without Tags	531	379	235	109	229	129
Captured	531	502	349	206	349	239
Released with Tags	531	497	349	206	348	239

[a] Fully recruited burbot are ≥450 mm TL.

Appendix B3. Mark and recapture history on burbot of all sizes[a] by year for the populations in Round Tangle, Sevenmile, Shallow Tangle, Upper Tangle, and Landlock Tangle lakes.

ROUND TANGLE LAKE				
DATE: Year	1986	1987	1988	1989
Beginning	7/21	7/27	6/15	6/24
Ending	8/25	8/25	6/19	7/28
NUMBER OF BURBOT OF ALL SIZES:				
Recaptured from Event 1	0	13	7	1
Recaptured from Event 2		0	15	5
Recaptured from Event 3			0	17
Captured with Tags	0	13	22	23
Captured without Tags	221	137	179	207
Captured	221	150	201	230
Released with Tags	191	146	193	220

SEVENMILE LAKE				
DATE: Year	1986	1987	1988	1989
Beginning	7/22	6/16	6/19	6/29
Ending	9/21	8/06	7/19	8/5
NUMBER OF BURBOT OF ALL SIZES:				
Recaptured from Event 1	0	51	5	2
Recaptured from Event 2		0	9	2
Recaptured from Event 3			0	9
Captured with Tags	0	51	14	13
Captured without Tags	198	158	41	39
Captured	198	209	55	52
Released with Tags	94	156	55	52

SHALLOW TANGLE LAKE				
DATE: Year	1986	1987	1988	1989
Beginning	7/21	7/29	6/13	6/22
Ending	8/18	8/30	6/16	7/26
NUMBER OF BURBOT OF ALL SIZES:				
Recaptured from Event 1	0	0	1	0
Recaptured from Event 2		0	2	0
Recaptured from Event 3			0	1
Captured with Tags	0	0	3	1
Captured without Tags	115	79	44	56
Captured	115	79	47	57
Released with Tags	52	65	47	56

-Continued-

Appendix B3. (Page 2 of 2).

UPPER TANGLE LAKE				
DATE: Year	1986	1987	1988	1989
Beginning	7/21	7/31	6/09	7/7
Ending	8/18	8/29	6/22	8/8
NUMBER OF BURBOT OF ALL SIZES:				
Recaptured from Event 1	0	5	2	1
Recaptured from Event 2		0	10	4
Recaptured from Event 3			0	5
Captured with Tags	0	5	12	10
Captured without Tags	101	69	97	86
Captured	101	74	109	96
Released with Tags	83	74	108	93

LANDLOCK TANGLE LAKE			
DATE: Year	1986	1987	1989
Beginning	7/20	6/30	7/9
Ending	7/24	8/7	8/11
NUMBER OF BURBOT OF ALL SIZES:			
Recaptured from Event 1	0	5	0
Recaptured from Event 2		0	7
Captured with Tags	0	5	7
Captured without Tags	50	222	146
Captured	50	227	153
Released with Tags	54	211	122

[a] Burbot are ≥300 mm TL.

Appendix B4. Mark and recapture histories for fully recruited[a] burbot by year (1987) and by sampling events (1988-89) for the populations in which mark-recapture experiments were compromised through tag loss and uncertainty of secondary marks.

MOOSE LAKE								
DATE: Year	1987	1987	1988	1988	1989	1989	1989	1989
Beginning	6/01	6/26	5/24	9/16	5/24	7/07	9/07	10/6
Ending	6/03	6/28	5/26	9/18	5/26	7/09	9/09	10/8
NUMBER OF FULLY RECRUITED BURBOT:								
Recaptured from Event 1	0	49	46	34	11	6	9	9
Recaptured from Event 2	0	0	12	6	6	2	2	2
Recaptured from Event 3	0	0	0	35or42	35or39	13	6	2
Recaptured from Event 3	0	0	0	0	66	6	7	2
Recaptured from Event 4	0	0	0	0	0	45	34	16
Recaptured from Event 5	0	0	0	0	0	0	28	8
Recaptured from Event 6	0	0	0	0	0	0	0	29
Captured with Tags	0	49	58	75or82	118or122	72	86	68
Captured without Tags	589	104	371	176or169	307or303	88	90	82
Captured	589	153	429	251	425	160	176	150
Released with Tags	589	153	426	251	425	160	174	150

HUDSON LAKE				
DATE: Year	1987	1988	1988	1989
Beginning	6/15	7/13	9/29	7/11
Ending	7/10	7/18	10/03	7/16
NUMBER OF FULLY RECRUITED BURBOT:				
Recaptured from Event 1	0	21	6or9	6
Recaptured from Event 2		0	10or13	6
Recaptured from Event 3			0	8
Captured with Tags	0	21	16or21	20
Captured without Tags	337	214	168or163	163
Captured	337	235	184	183
Released with Tags	337	231	142	145

[a] For all populations, burbot ≥ 450 mm TL were considered fully recruited to the gear while smaller fish were considered to be partially recruited.

Appendix B5. Voluntary returns of tagged burbot by sport anglers.

Lake Date Tagged	Tag Number	Date Caught	Recapture Location	Lake Date Tagged	Tag Number	Date Caught	Recapture Location
Sucker				Tolsona			
6/12/87	3655	2/27/89	Sucker	5/27/88	42968	1/3/89	Tolsona
9/30/87	43977	2/17/89	Sucker	9/25/86	38749	4/2/89	Tolsona
6/12/87	3692	2/17/89	Sucker	9/25/86	38980	4/2/89	Tolsona
6/12/87	3707	2/17/89	Sucker	9/24/86	38572	3/18/89	Tolsona
Beaver				6/4/87	88075	3/18/89	Tolsona
9/22/88	43749	3/17/89	Beaver	9/2/88	45650	3/18/89	Tolsona
6/27/88	43510	3/17/89	Beaver	8/5/86	37706	3/18/89	Tolsona
6/27/88	45123	4/9/89	Beaver	6/4/87	39866	3/18/89	Tolsona
6/12/88	44547	4/9/89	Susitna	6/4/87	39547	4/10/89	Tolsona
6/28/88	45167	5/5/89	Beaver	6/4/87	39638	4/10/89	Tolsona
9/24/88	43835	5/4/89	Beaver	6/4/87	39985	4/10/89	Tolsona
Crosswind				5/24/89	46858	11/27/89	Tolsona
7/23/88	45354	2/26/90	Crosswind	9/2/88	45790	11/27/89	Tolsona
Lake Louise				9/2/88	45788	3/10/90	Tolsona
6/15/88	43214	3/24/89	Lk Louise	6/4/87	39031	1/7/90	Tolsona
6/15/88	44634	3/1/89	Susitna	6/4/87	39072	1/21/90	Tolsona
6/20/88	43329	3/18/89	Lk Louise	9/24/86	38878	2/12/90	Tolsona
7/24/87	40487	3/31/89	Susitna	6/4/87	39966	2/18/90	Tolsona
6/20/88	43354	3/17/89	Lk Louise	6/4/87	39995	2/18/90	Tolsona
6/23/88	43461	3/18/89	Lk Louise	5/27/88	41639	2/18/90	Tolsona
6/11/89	43061	3/18/89	Lk Louise	5/27/88	42926	2/18/90	Tolsona
8/14/87	41118	7/2/89	Lk Louise	5/24/89	46773	2/18/90	Tolsona
7/22/87	40411	11/20/88	Susitna	5/24/89	46895	2/18/90	Tolsona
8/19/87	41180	7/4/89	Lk Louise	9/2/88	45669	2/18/90	Tolsona
Susitna				9/12/89	143420	2/18/90	Tolsona
7/26/87	40570	3/1/89	Susitna	6/4/87	39591	2/18/90	Tolsona
6/9/88	44166	3/1/89	Tyone	Moose			
9/22/88	43763	3/9/89	Beaver	5/26/88	41903	12/27/89	Moose
6/20/88	44863	4/18/89	Susitna	Paxson			
6/14/88	44581	4/19/89	Susitna	8/14/86	37305	6/10/89	Paxson
Tyone				6/25/88	63282	4/16/89	Paxson
6/10/88	44395	2/10/89	Tyone	6/24/88	63247	4/16/89	Paxson
9/1/87	41473	6/17/89	Tyone	7/10/87	24424	4/16/89	Paxson
8/22/87	41251	8/27/89	Susitna	7/12/86	30633	9/20/89	Paxson
				6/29/88	63475	7/14/89	Paxson

- Continued -

Appendix B5. (Page 2 of 2).

Lake Date Tagged	Tag Number	Date Caught	Recapture Location
Summit			
7/12/86	30748	7/4/89	Summit
Round Tangle			
7/21/86	37414	7/??/89	Rd Tangle
Harding			
6/20/87	31845	1/2/89	Unknown
6/20/87	31848	3/22/89	Unknown
7/8/86	33932	3/12/89	Harding
7/8/86	33940	4/20/89	Harding
6/18/87	24983	4/24/89	Harding
7/8/86	33944	4/26/89	Harding
6/20/87	31836	4/19/89	Harding
6/16/87	24972	4/18/89	Harding
6/18/87	31780	4/27/89	Harding
7/9/86	33978	4/17/89	Harding
7/8/86	33939	4/21/89	Harding
6/18/87	31800	4/23/89	Harding
George			
6/9/89	10380	3/19/90	George

Appendix B6. Numbers of burbot killed during sampling in 11 lakes in interior Alaska in 1989.[a]

Lake	Fully Recruited	Partially Recruited	Lake	Fully Recruited	Partially Recruited
Summit	0	1	Tolsona	0	0
Fielding	5	6	Hudson	38	1
Sevenmile	0	0	Louise	4	3
T	1	3	Susitna	4	1
Landlock Tangle	2	32	Tyone	0	0
Shallow Tangle	0	1	Paxson	0	0
Upper Tangle	3	0	Moose	3	1
Round Tangle	1	7			
Harding	0	4			
Jack	0	3			
George	0	0			
TOTAL	28	29		49	5

[a] Fully recruited burbot are ≥ 450 mm TL.

Appendix B7. 1989 data archive.

Location	Project Leader	Storage Softwear and version
Region II Palmer	R. Lafferty 745-5016	Comma delimited ASCII files Standard RTS Archive format[a]

Data Map

Lake	File Name	Data Format	Softwear
Hudson	I0090la9.dta	Tagging Length	RTS-ASCII
	I0090ta9.dta	Trap Net	RTS-ASCII
	Hudso_th.wkl	Tag History	Lotus
Louise	I0100l-9.dta	Tagging Length	RTS-ASCII
	I0100t-9.dta	Trap Net	RTS-ACSII
	Louie_th.wkl	Tag History	Lotus
Moose	I2270l-9.dta	Tagging Length	RTS-ASCII
	I2270t-9.dta	Trap Net	RTS-ASCII
	Moose_th.wkl	Tag History	Lotus
Paxson	I0130l-9.dta	Tagging Length	RTS-ASCII
	I0130t-9.dta	Trap Net	RTS-ASCII
	Paxs_th.wkl	Tag History	Lotus
Susitna	I0110l-9.dta	Tagging Length	RTS-ASCII
	I0110t-9.dta	Trap Net	RTS-ASCII
	Susit_th.wkl	Tag History	Lotus
Tolsona	I2860l-9.dta	Tagging Length	RTS-ASCII
	I2860t-9.dta	Trap Net	RTS-ASCII
	Tol_th.wkl	Tag History	Lotus
Tyone	I0120l-9.dta	Tagging Length	RTS-ASCII
	I0120t-9.dta	Trap Net	RTS-ASCII
	Tyone_th.wkl	Tag History	Lotus

-Continued-

Appendix B7. (Page 2 of 4).

Location	Project Leader	Storage Softwear and version
Region III Delta Jct.	F. Parker 895-4632	Comma delimited ASCII files Standard RTS Archive format[a]

Data Map

Lake	File Name	Data Format	Softwear
Fielding	U0130la9.dta	Tagging Length	RTS-ASCII
	U0130ta9.dta	Trap Net	RTS-ASCII
	Field_th.wkl	Tag History	Lotus
George	U0110la9.dta	Tagging Length	RTS-ASCII
	George89.wk!	Trap net CPUE	Lotus (sqz)[b]
	Geo89-th.wk!	Tag History	Lotus (sqz)
Harding	U1890la9.dta	Tagging Length	RTS-ASCII
	Hard89I .wk!	Trap net CPUE	Lotus (sqz)
	Hard89th.wk!	Tag History	Lotus (sqz)
Jack	U3620la9.dta	Tagging Length	RTS-ASCII
	Jack89M .wk!	Trap net CPUE	Lotus (sqz)
	Jack-th .wk!	Tag History	Lotus (sqz)
Landlock Tangle	U015ela9.dta	Tagging Length	RTS-ASCII
	U015elc9.dta	Tagging Length	RTS-ASCII
	Lltan89M.wk!	Trap net CPUE	Lotus (sqz)
	Lltan89R.wk!	Trap net CPUE	Lotus (sqz)
	Ltan89th.wk!	Tag History	Lotus (sqz)
Round Tangle	U015cla9.dta	Tagging Length	RTS-ASCII
	U015clb9.dta	Tagging Length	RTS-ASCII
	Round89M.wk!	Trap net CPUE	Lotus (sqz)
	Round89R.wk!	Trap net CPUE	Lotus (sqz)
	Rtan89th.wk!	Tag History	Lotus (sqz)
Shallow Tangle	U015bla9.dta	Tagging Length	RTS-ASCII
	U015blb9.dta	Tagging Length	RTS-ASCII
	Shall89M.dta	Trap net CPUE	Lotus (sqz)
	Shall89R.dta	Trap net CPUE	Lotus (sqz)
	Shtan-th.wkl	Tag History	Lotus (sqz)

-Continued-

Appendix B7. (Page 3 of 4).

Location	Project Leader	Storage Softwear and version
Region III Delta Jct.	F. Parker 895-4632	Comma delimited ASCII files Standard RTS Archive format[a]

Data Map

Lake	File Name	Data Format	Softwear
Upper Tangle	U015d1a9.dta	Tagging Length	RTS-ASCII
	U015d1b9.dta	Tagging Length	RTS-ASCII
	Uptan89M.wk!	Trap net CPUE	Lotus (sqz)
	Uptan89R.wk!	Trap net CPUE	Lotus (sqz)
	Uptan-th.wk!	Tag History	Lotus
Sevenmile	U3060la9.dta	Tagging Length	RTS-ASCII
	U3060la9.dta	Tagging Length	RTS-ASCII
	Seven89M.wk!	Trap net CPUE	Lotus (sqz)
	Seven89R.wk!	Trap net CPUE	Lotus (sqz)
	Sev89-th.wk!	Tag History	Lotus (sqz)
Summit	I0140la9.dta	Tagging Length	RTS-ASCII
	Sumit89I.wk!	Trap net CPUE	Lotus (sqz)
	Sumit-th.wk!	Tag History	Lotus (sqz)
T	U3370la9.dta	Tagging Length	RTS-ASCII
	U3370lb9.dta	Tagging Length	RTS-ASCII
	Tee89M .wk!	Trap net CPUE	Lotus (sqz)
	Tee89R .wk!	Trap net CPUE	Lotus (sqz)
	Tee89th .wk!	Tag History	Lotus (sqz)

-Continued-

Definitions of Data Formats:

Tagging Length: a mark-sense form developed by Alaska Department of Fish and Game, Division of Sport Fish-Research and Technical Services (RTS) for the recording of length and tag information.

Trap Net: a mark-sense form developed by RTS for the recording of CPUE information of traps.

Tag History: a LOTUS spreadsheet designed to record individual tag deployment and recaptures by sampling events.

Specific codes and organization of columns for each data format are available on request from RTS.

[a] Alaska Department of Fish and Game - Sport Fish Division - Research and Technical Services (RTS).
[b] Lotus squeezed file - (wk!) - Turner Hall Publishing 1986, version 1.5.

Appendix B8. Estimates of mortality rates, recruitment, and abundance from Jolly-Seber and other methods for several populations of burbot (≥ 450 mm TL) from interior Alaskan lakes.

	Date and Abundance		Survival Rate	Date and Abundance		Survival Rate	Date and Abundance		Survival Rate	Date and Abundance		Survival Rate	
	Recruitment			Recruitment			Recruitment			Recruitment			
Fielding	10/5/84	355 days	9/25/85	332 days			9/2/86	325 days		7/24/87	341 days		7/15/88
Estimate	N/A		33.2%	267	165	45.8%	322	36	37.8%	216	238	11.4%	continued
SE			12.5%	69	73	6.3%	56	33	6.0%	22	48	11.6%	next
CV				25.8%			17.4%			10.2%			line
Fielding	7/15/88	345 days	6/27/89[a]										
Estimate	411	118	44.4%	332									
SE	63	42	11.2%	68									
CV	15.3%			19.9%									
Tolsona	10/2/86	237 days	6/3/87	353 days			5/26/88	96 days		9/01/88	267 days		5/24/89
Estimate	1,901	138	44.1%	1,205	98	28.9%	1,454	451	33.5%	1,005	600	36.4%	1,092
SE	120	209	4.2%	116	159	6.8%	164	97	8.5%	131	127	9.7%	148
CV	6.3%			9.6%			11.4%			13.1%			13.6%
Paxson	7/10/86	365 days	7/10/87	336 days			6/26/88						
Estimate	9,111	1,787	46.1%	3,883	-29	37.4%	2,402						
SE	1,996	1,392	6.8%	577	318	13.8%	539						
CV	21.6%			14.9%			22.4%						
Louise	6/27/86	381 days	7/13/87	330 days			6/16/88						
Estimate	6,990	1,864	64.8%	5,978	538	50.5%	3,458						
SE	2,131	2,032	11.9%	1,896	962	11.3%	904						
CV	30.5%			31.7%			26.1%						
Round[b] Tangle	8/05/86	370 days	8/10/87	312 days			6/18/88	373 days		6/26/89			
Estimate	1,241		62.4%	774	370	64.8%	642	529	64.8%	755			
SE	379		12.2%	311	188	12.7%	243	281	12.7%	358			
CV	30.5%			40.2%			37.9%			47.4%			

[a] Duration between the middle of sampling events or group of sampling events.

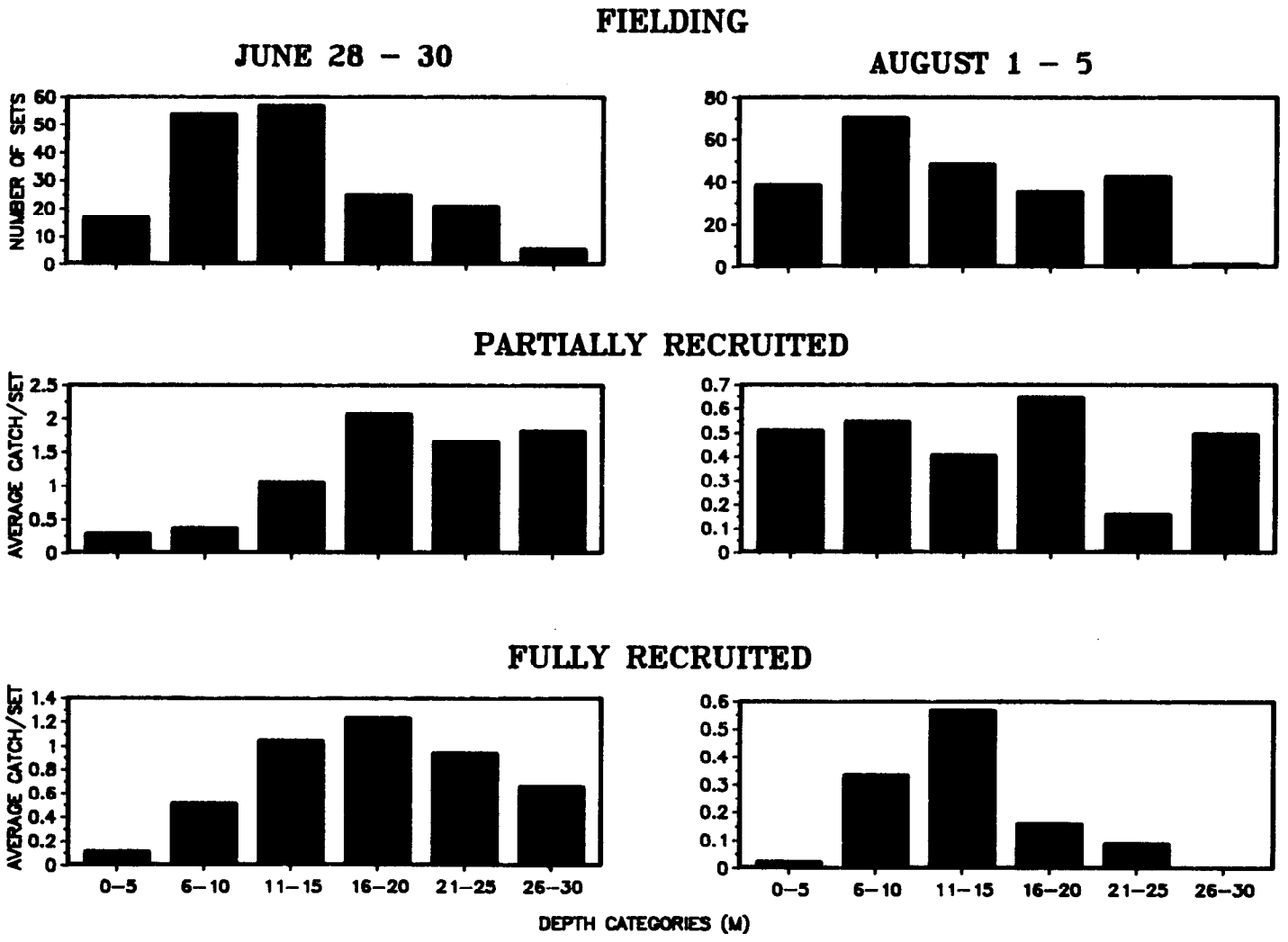
[b] Statistics for the population in Round Tangle Lake are for burbot larger than 299 mm TL.

Appendix B9. Possible extremes in estimates of mortality rates, recruitment, and abundance for fully recruited burbot (≥ 450 mm TL) in mark-recapture experiments compromised through tag loss and uncertainty of secondary marks.

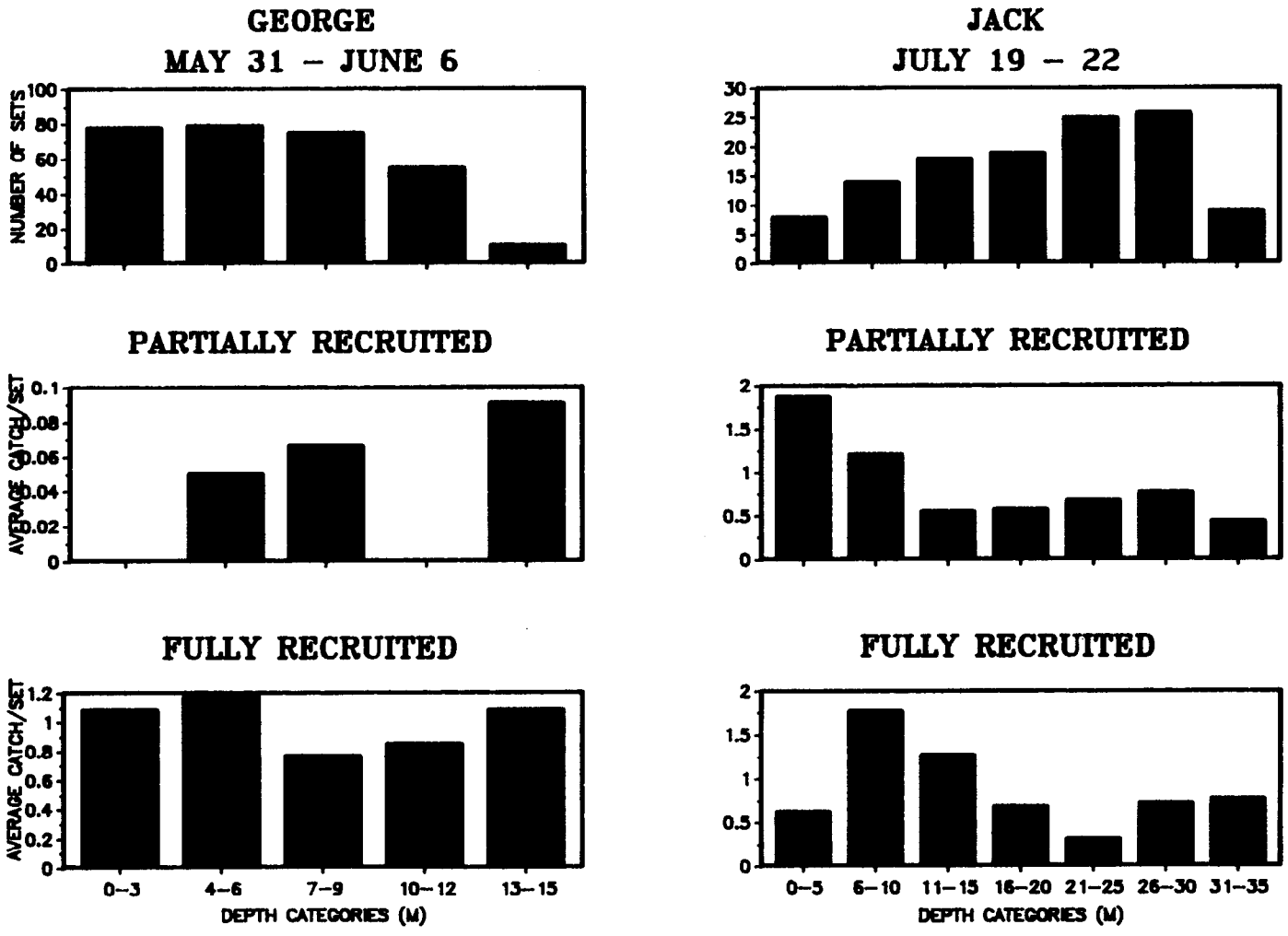
	Date and[a] Abundance	Recruitment	Survival Rate	Date and Abundance	Recruitment	Survival Rate	Date and Abundance	Recruitment	Survival Rate	Date and Abundance
		——337 days——		5/24/88	——113 days——		9/16/88	——247 days——		5/21/89
	Lower Estimate	1,732	51.1%	2,884	-312	49.3%	1,150	696	26.2%	1,544 continued
MOOSE	6/24/87	342	9.0%	403	203	6.0%	138	138	9.2%	185 below
Estimate	2,357			14.0%			12.0%			12.0%
SE	448									
CV	5.2%									
	Upper Estimate	1,909	46.2%	3,178	-266	54.3%	1,185	697	25.2%	1,582 continued
		385	10.2%	461	201	5.6%	147	146	9.3%	193 below
				14.5%			12.4%			12.2%
MOOSE	5/21/89	——50 days——		7/10/89	——67 days——		9/15/89			
	Lower Estimate	30	36.2%	1,016	79	42.1%	668			
		111	10.2%	170	66	12.1%	119			
				16.7%			17.8%			
	Upper Estimate	6	36.2%	1,016	79	42.1%	668			
		113	10.3%	170	66	12.1%	119			
				16.7%			16.7%			
		—— 31 days——		7/7/87	——408 days——		8/26/88			
	Lower Estimate	637	42.1%	2,092		48.5%	1,711			
HUDSON	6/7/87	481	17.5%	747		22.2%	766			
Estimate	3,671			35.7%			44.8%			
SE	705									
CV	19.2%									
	Upper Estimate	1,237	45.2%	1,982		48.9%	2,249			
		767	18.4%	762		22.8%	1,071			
				38.4%			47.6%			

[a] Estimates for 1987 were obtained from Parker et al. (1988).

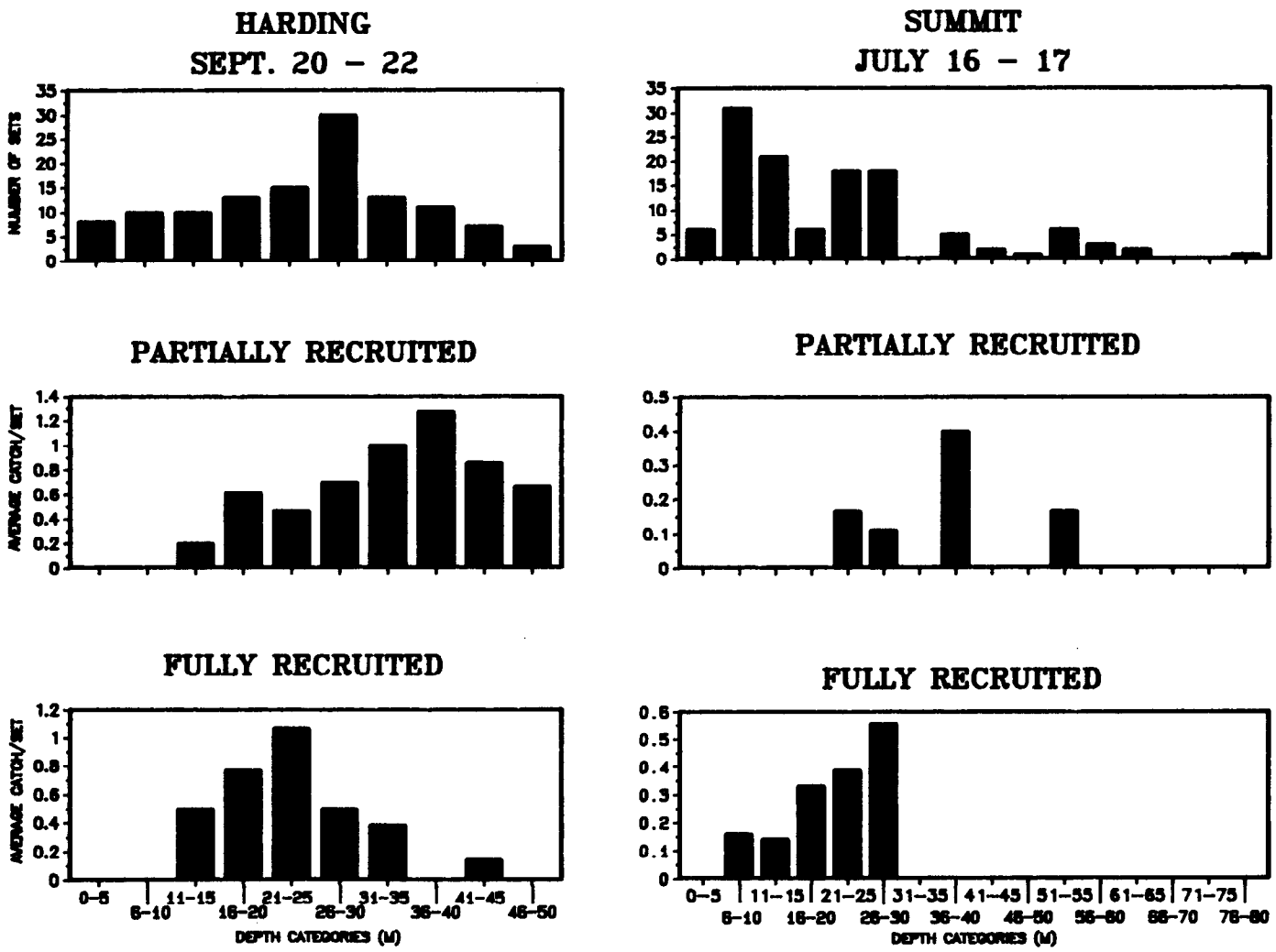
Appendix C: Appendix Figures



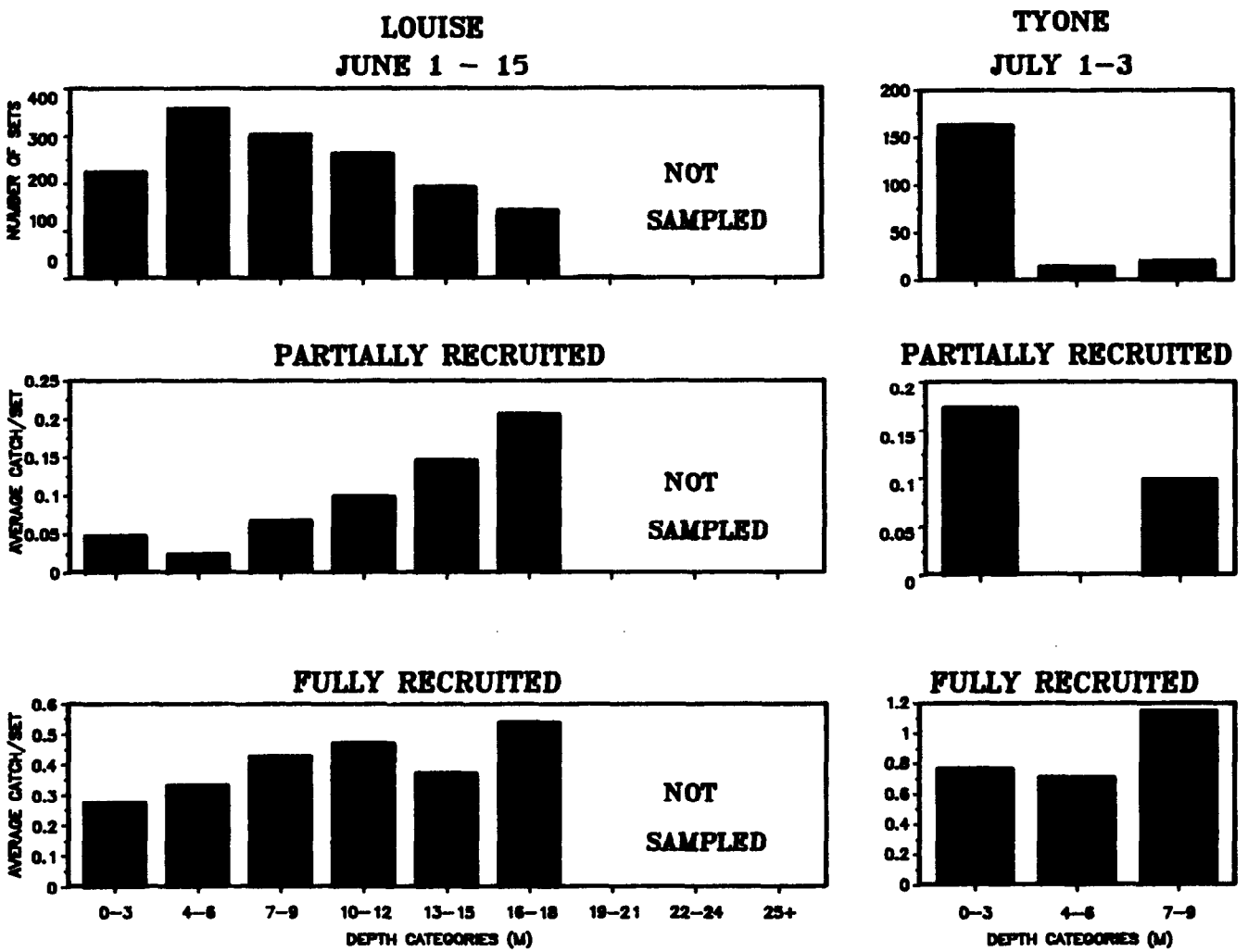
Appendix C1. Frequency of sets by depth and average catch by depth of fully (≥ 450 mm TL) and partially (< 450 mm TL) recruited burbot for the sampling events in Fielding Lake in 1989.



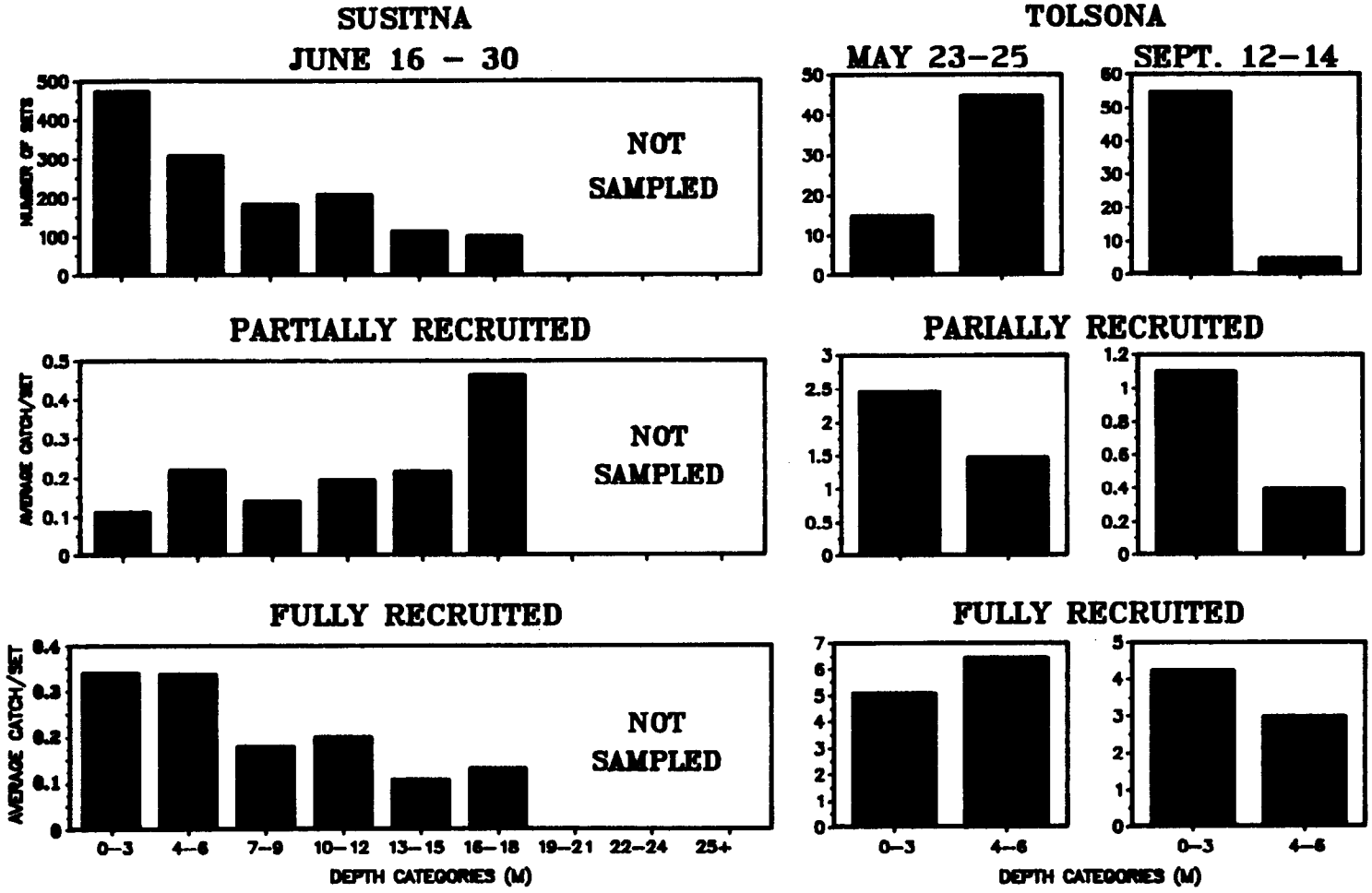
Appendix C2. Frequency of sets by depth and average catch by depth of fully (≥ 450 mm TL) and partially (< 450 mm TL) recruited burbot for the sampling events in George and Jack lakes in 1989.



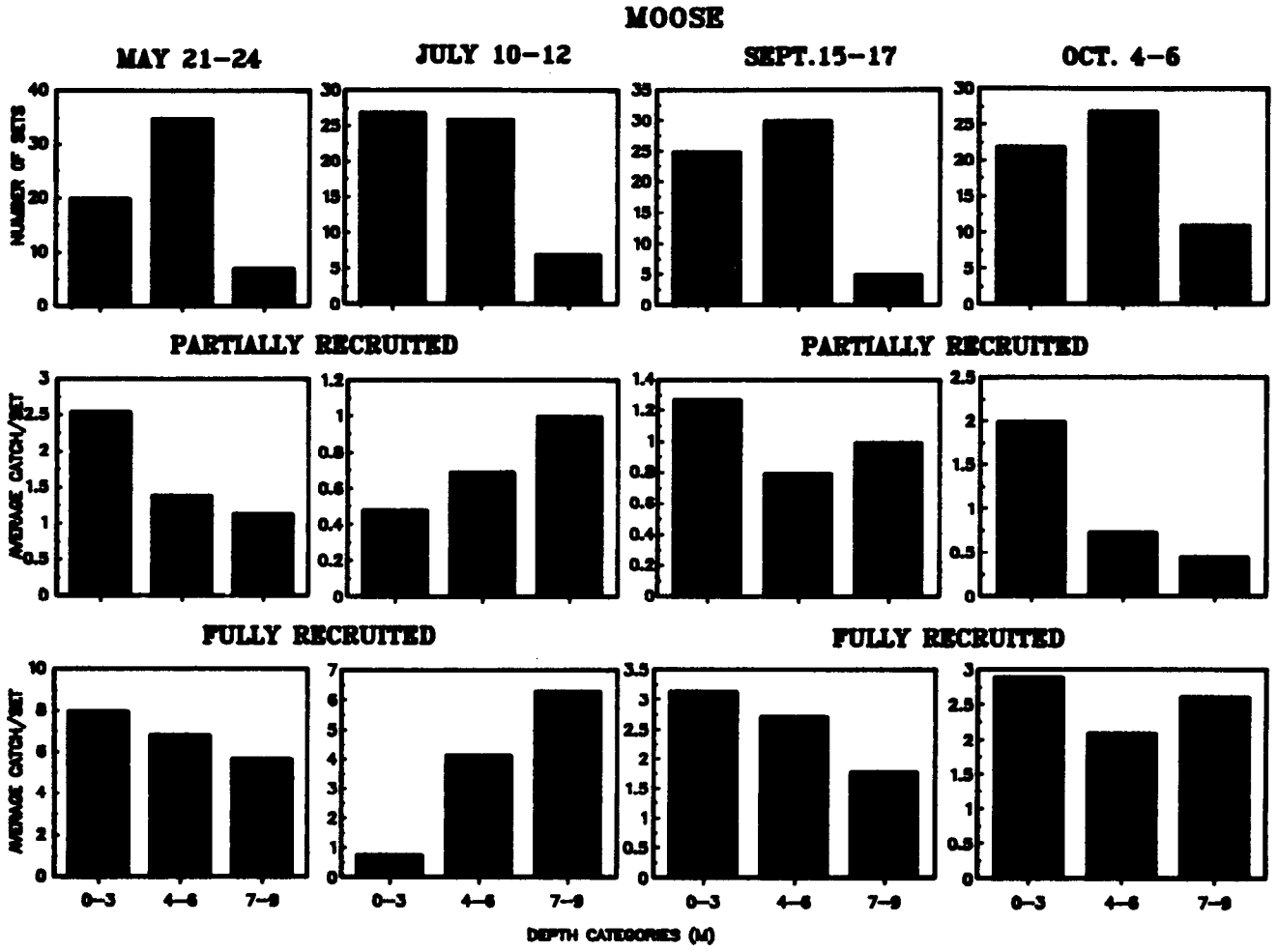
Appendix C3. Frequency of sets by depth and average catch by depth of fully (≥ 450 mm TL) and partially (< 450 mm TL) recruited burbot for the sampling events in Harding and Summit lakes in 1989.



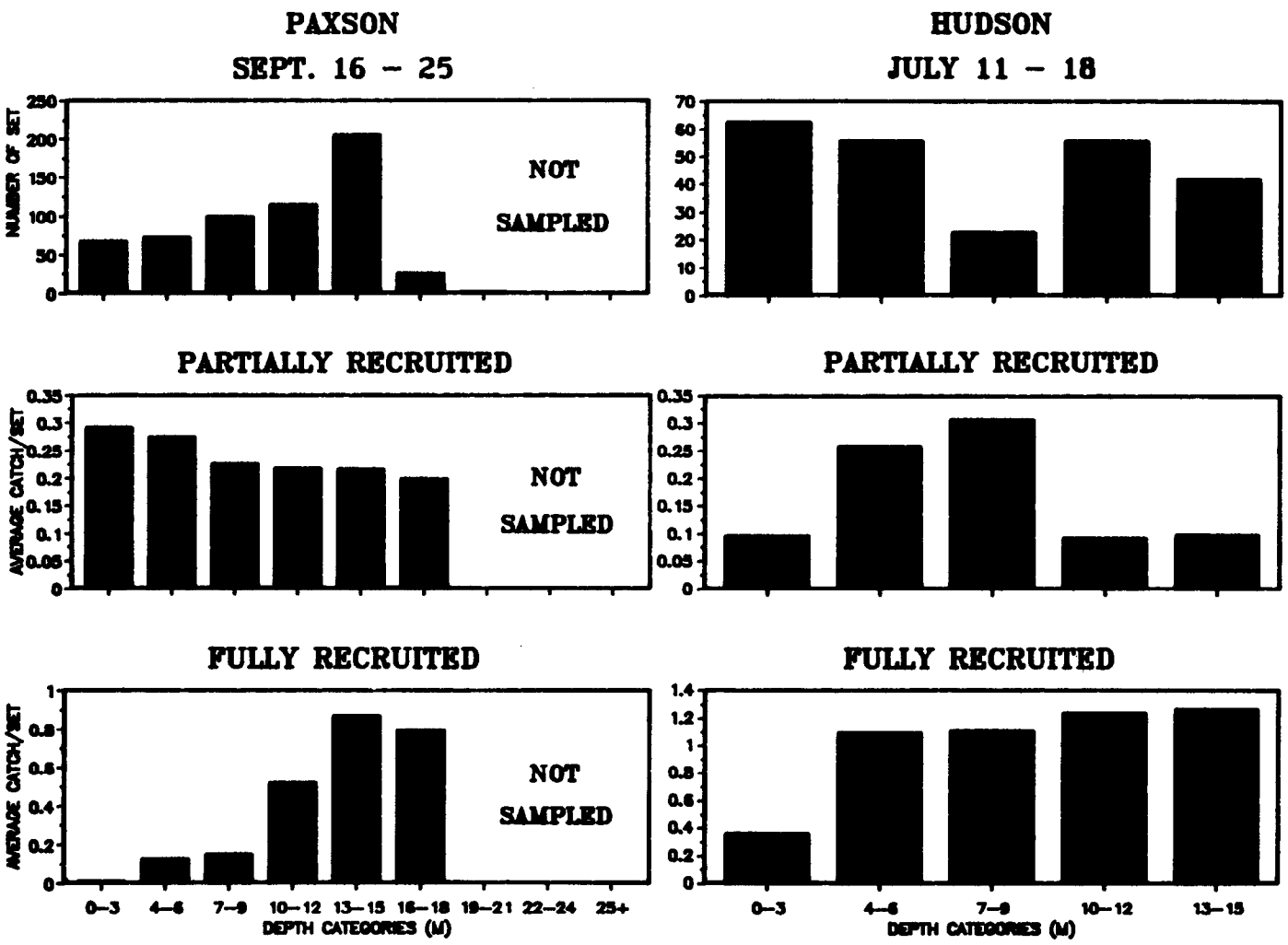
Appendix C4. Frequency of sets by depth and average catch by depth of fully (≥ 450 mm TL) and partially (< 450 mm TL) recruited burbot for the sampling events in Lake Louise and Tyone Lake in 1989.



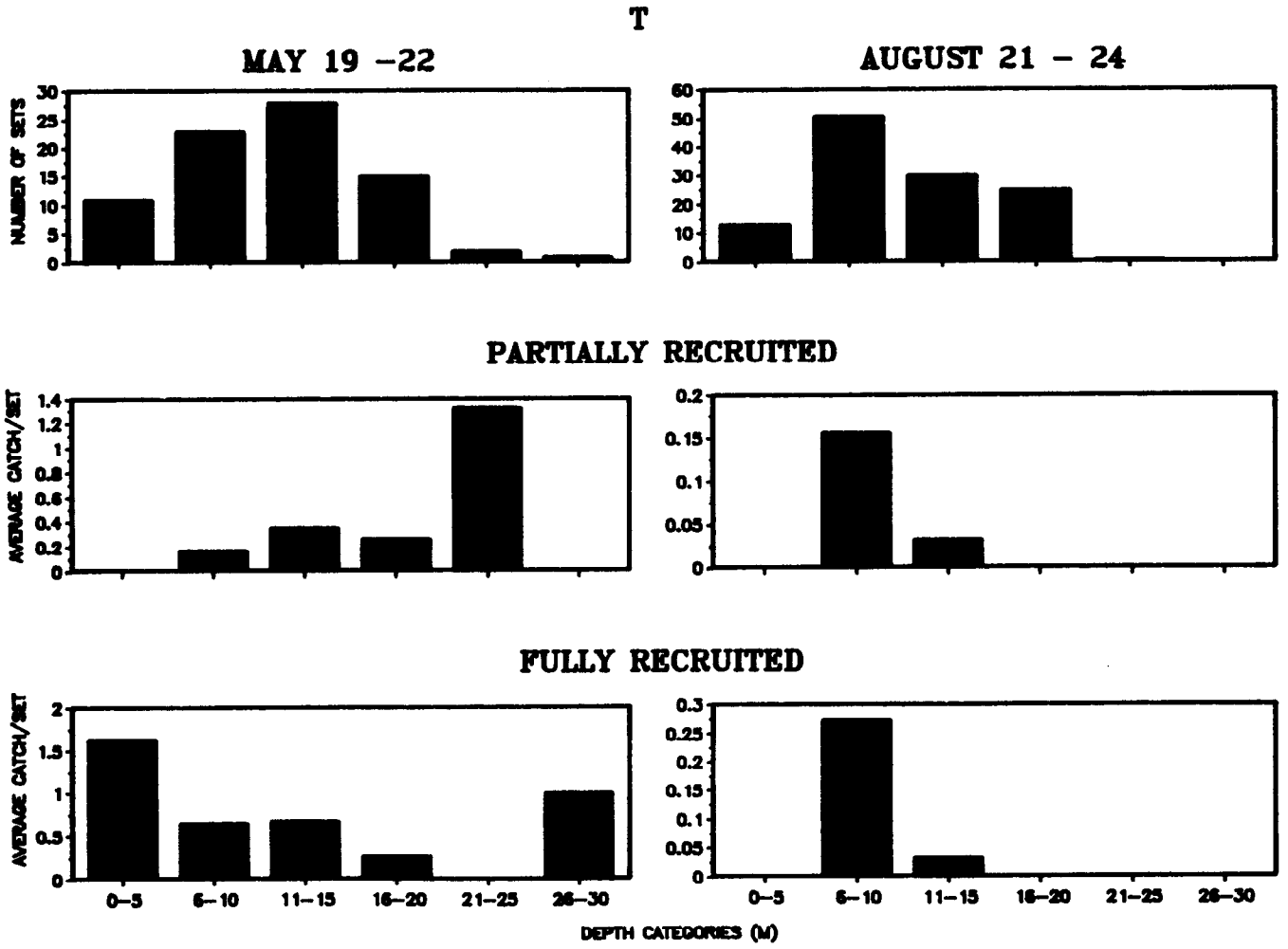
Appendix C5. Frequency of sets by depth and average catch by depth of fully (≥ 450 mm TL) and partially (< 450 mm TL) recruited burbot for the sampling events in Susitna and Tolsona lakes in 1989.



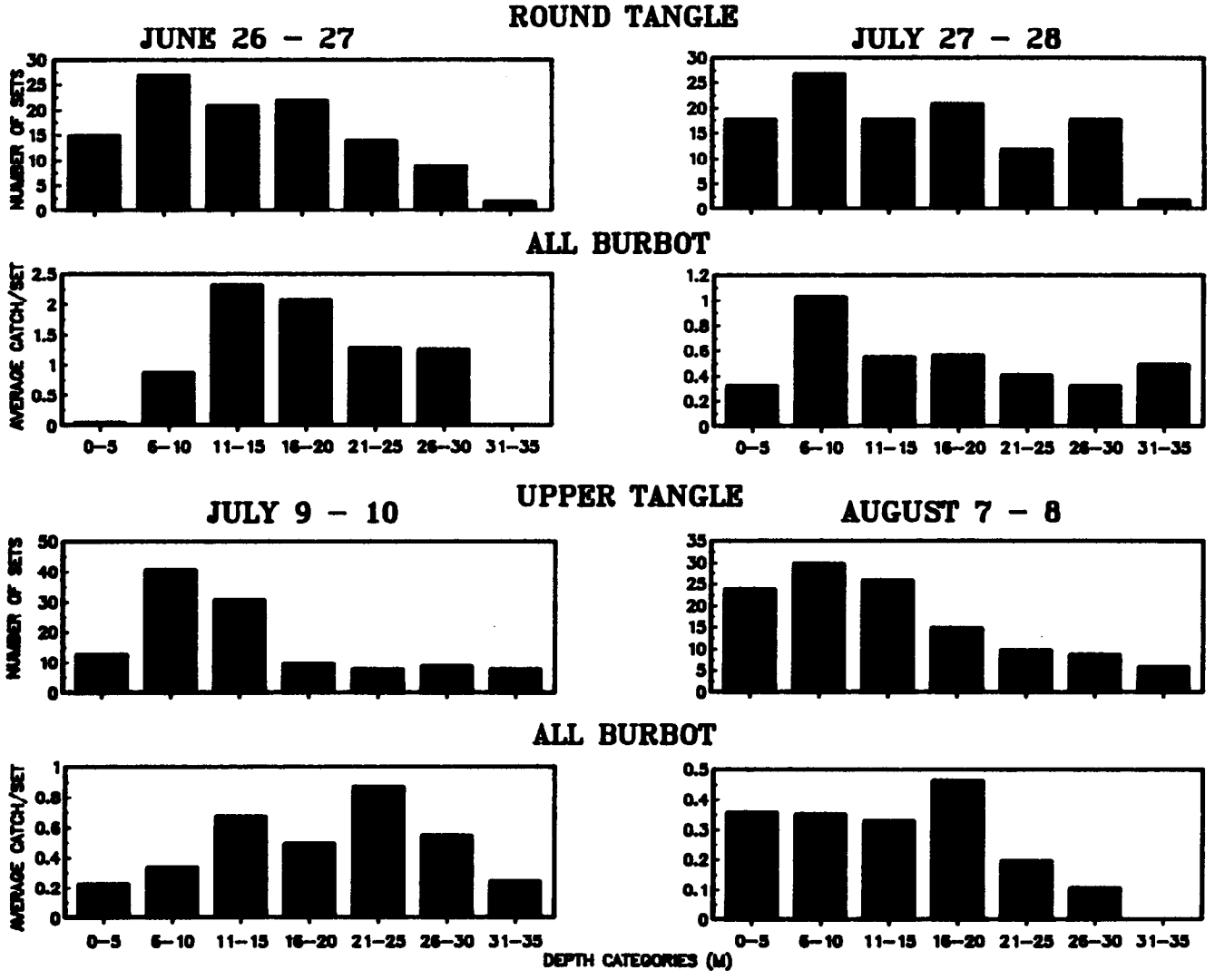
Appendix C6. Frequency of sets by depth and average catch by depth of fully (≥ 450 mm TL) and partially (< 450 mm TL) recruited burbot for the sampling events in Moose Lake in 1989.



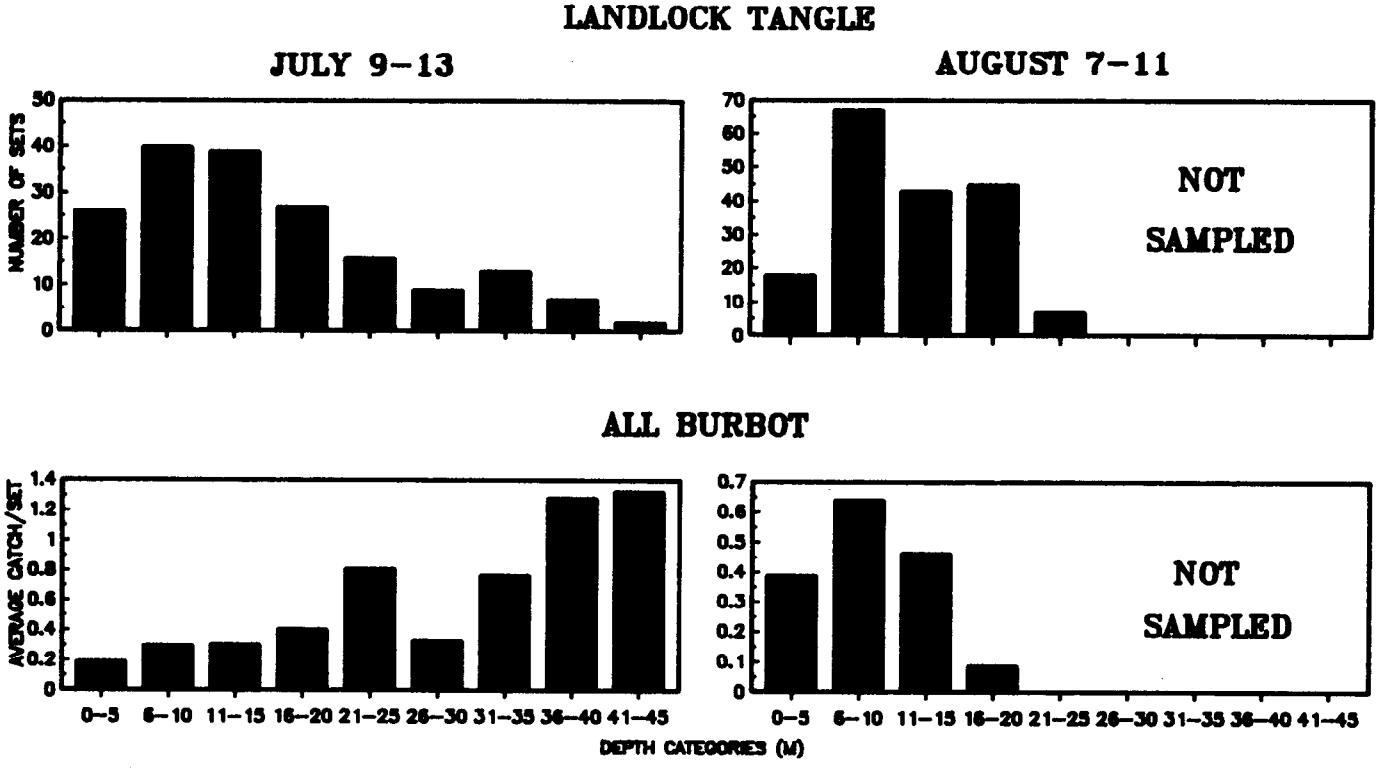
Appendix C7. Frequency of sets by depth and average catch by depth of fully (≥ 450 mm TL) and partially (< 450 mm TL) recruited burbot for the sampling events in Paxson and Hudson lakes in 1989.



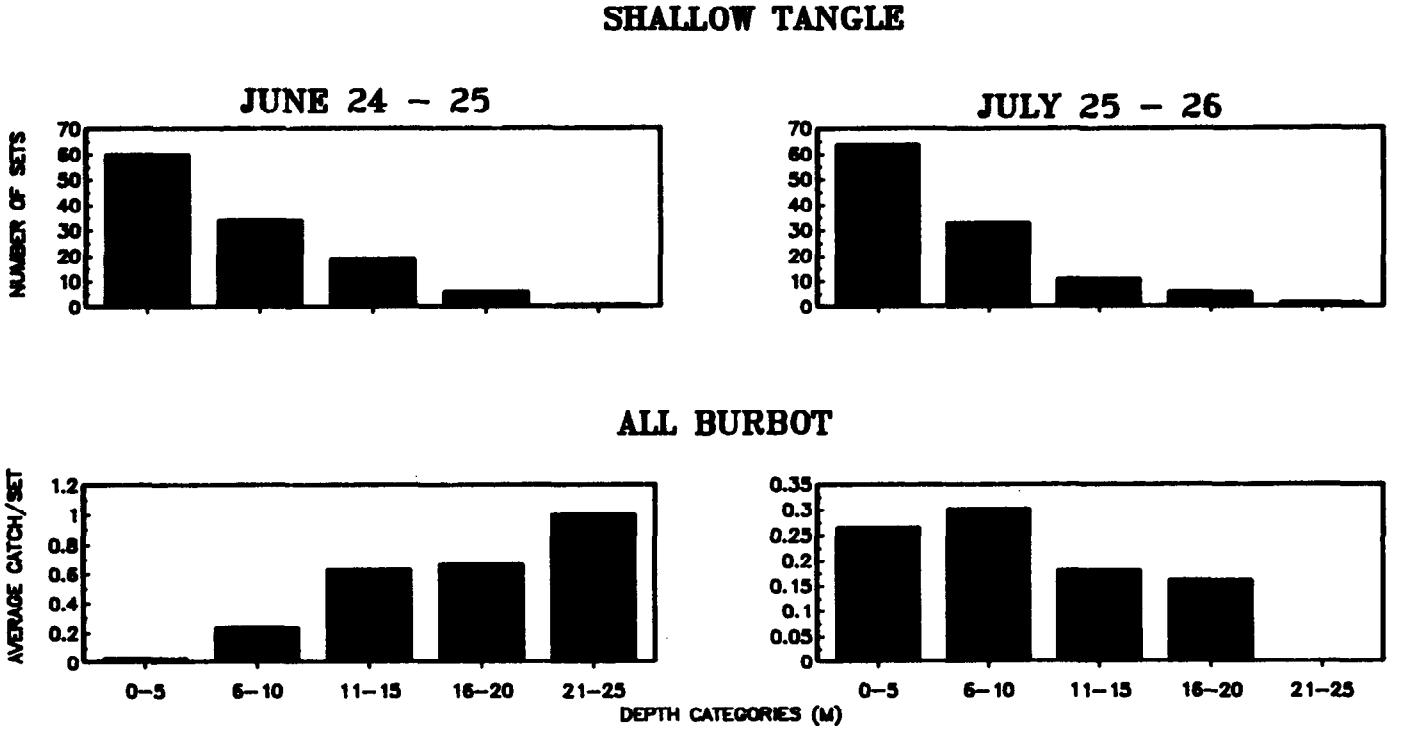
Appendix C8. Frequency of sets by depth and average catch by depth of fully (≥ 450 mm TL) and partially (< 450 mm TL) recruited burbot for the sampling events in T Lake in 1989.



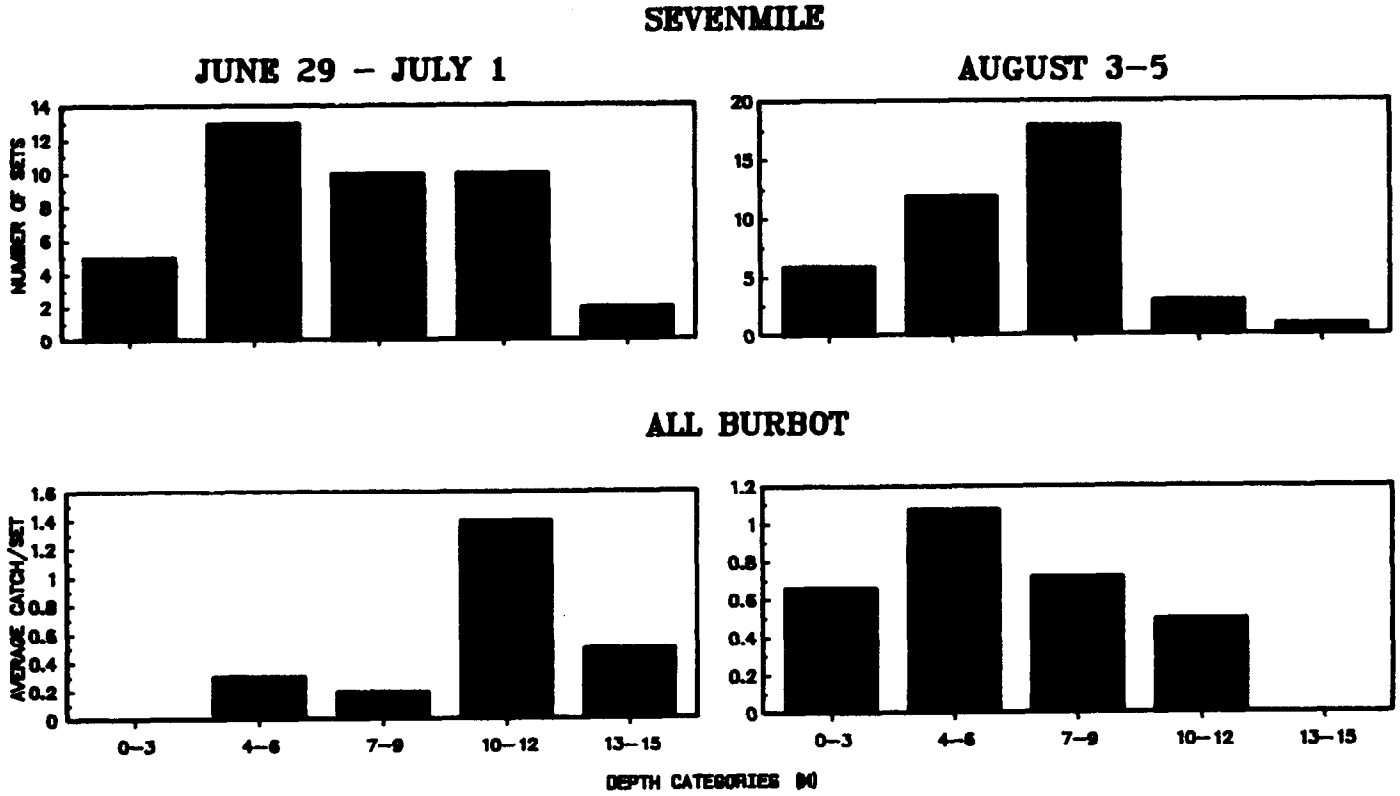
Appendix C9. Frequency of sets by depth and average catch by depth of all burbot (≥ 300 mm TL) for the sampling events in Round Tangle and Upper Tangle lakes in 1989.



Appendix C10. Frequency of sets by depth and average catch by depth of all burbot (≥ 300 mm TL) for the sampling events in Landlock Tangle Lake in 1989.



Appendix C11. Frequency of sets by depth and average catch by depth of all burbot (≥ 300 mm TL) for the sampling events in Shallow Tangle Lake in 1989.



Appendix C12. Frequency of sets by depth and average catch by depth of all burbot (≥ 300 mm TL) for the sampling events in Sevenmile Lake in 1989.